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PAPERS.

I. *The Chronology of Star Catalogues* By E. B Knobel, Esq

The History of Star Catalogues is a branch of Astronomy on which English literature appears to be very deficient I have therefore reduced the following researches into a form available for reference, in the hope that they might to some extent fill up the gap that exists, and give more complete information on this department of Sidereal Astronomy

The Table of 530 Star Catalogues which is appended, I have endeavoured to make exhaustive of the labours of Astronomers in this direction. I cannot suppose it to be perfect, but the omissions will, I trust, be found few and unimportant

No Catalogue is inserted in the Table, with very few exceptions, which has not been personally examined The exceptions consist entirely of Ancient and Oriental Catalogues either untranslated or which are not to be found in our Public Libraries, these are marked with an asterisk

Following the Table of Catalogues of the Positions of Stars will be found a List of 29 Catalogues of Proper Motions of Stars.

The Memoir which follows, consists mainly of notes on some of the less well-known Catalogues, the No of the paragraph is that under which the particular Catalogue is referred to in the Table

1 The earliest observations of Stars, undertaken for the purpose of identifying their relative positions, appear to have been made by Eudoxus, a disciple of Plato, about the period B C. 368 to 352 He is said to have introduced Astronomy into Greece from Egypt His observations were recorded by Aratus, from whom we derive all our information of them. Riccioli* gives the N P D. of 25 Stars, and Tycho Brahe† the N.P.D. of

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* *Astronomiæ Reformatæ*, tom 1 p 204

† *Historia Cœlestis*, tom 1 p vii

47 Stars determined by EUDOXUS, extracted from the Astronomical Poem of ARATUS, B.C 281.

2 The next Catalogue of Stars (by which we understand, properly speaking, a list of stars, showing their relative positions with respect to some known or assumed great circle) was made by ARISTILLUS and TIMOCHARIS about B C 300 All we know of these Astronomers we derive from PTOLEMY's *Almagest*, enough to show us how valuable their observations proved to their successors. MONTUCLA says[*]: "They appear to have been the first Astronomers to determine the position of fixed stars with respect to the Zodiac, marking their positions by longitude and latitude, and if we can judge from a considerable number of their observations noticed by PTOLEMY, they were the first to entertain the idea of forming a Catalogue of Stars." They did not confine themselves to the Zodiac, as may be seen in PTOLEMY. The *Almagest*[†] contains the Declinations of 18 Stars observed by them for the Epoch B C 283 They observed for 26 years from B.C 295, the date of their first known observation

For more than 100 years we have no record of observations for determining the position of stars ARATUS, to whom we owe our knowledge of the observations of EUDOXUS, was probably not an Astronomer at all.[‡]

3. HIPPARCHUS, B C 160 to 125, was the most celebrated Astronomer among the Greeks. The sudden apparition of a new star[§] induced him, as a similar phenomenon did TYCHO BRAHE many centuries later, to enumerate the visible stars, so as to know whether they appeared and disappeared He is said to have constructed his Catalogue by the method of alineations,[||] indicating those that are in the same apparent straight line Our knowledge of it is derived mainly from PTOLEMY, but there appears to be a doubt how it was originally formed It is said[¶] he first used Right Ascensions and Declinations for the positions of stars, which he afterwards abandoned in favour of longitudes and latitudes. HUMBOLDT says:[**] "In HIPPARCHUS' *Commentary* all positions are referred to the Equator by Right Ascension

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[*] *Histoire des Mathématiques*, vol 1 p 217

[†] PTOLEMY, *Almagest (Halma)*, vol ii p 16

[‡] CAUSSIN, *Notices et Extraits des MSS*, vol xii p 239

[§] PLINY, bk ii ch xxiv

[||] DRAPER, *Religion and Science*, p 29

[¶] *Penny Cycl*, vol ii p 531

[**] *Cosmos Phy Description of Heavens*, p 92.

and Declination" MONTUCLA conjectures* that "HIPPARCHUS described the Constellations with their stars on a solid globe, and that he placed this sphere in the school of Alexandria; for PTOLEMY, desiring to prove that the relative position of the stars had not changed since HIPPARCHUS, requests that they may be compared with the positions on the solid globe of that Astronomer"

The Catalogue of HIPPARCHUS is supposed to have contained the positions of 1080 stars for the Epoch B.C. 128 ACHILLES TATIUS (A D 400) in his work, designated by PETAVIUS† under the title *Ad Arati Phænomena qui liber falso Eratostheni tribuitur*, says: "Stellas omnes HIPPARCHUS asserit esse 1080 quæ nimirum constellationes apparentes efficiunt."

4 MENELAUS, at the period A.D. 97, according to M. J. J. SÉDILLOT,‡ constructed a Catalogue of Stars from that of HIPPARCHUS, and PTOLEMY founded his Catalogue upon that of MENELAUS. DELAMBRE says·§ "STADIUS appears to have thought that MENELAUS made a Catalogue at Rome 99 years after J.C —'Post natum Christum uti ex Ptolemæo colligitur annos 99 stellas fixas observavit.'"‖ This fact is not mentioned by Mr. BAILY in his Preface to PTOLEMY'S Catalogue¶, indeed, he there remarks: "After the death of HIPPARCHUS . . . no successor arose worthy of the name of an Astronomer till the time of PTOLEMY." But the statement of SÉDILLOT is based probably upon a passage in the *Preface to the Description of the Stars*, by the Persian Astronomer ABD-AL-RAHMAN AL-SÛFI Professor SCHJELLERUP'S translation of this work has been recently published at St. Petersburg, from which I extract the following paragraph. AL-SÛFI writes in his Preface:—**

"Quant aux lieux des étoiles par rapport aux signes du Zodiaque, j'ai trouvé que PTOLEMÉE s'est appuyé sur les observations de MÉNÉLAUS, faites l'an 845 de NABONASSAR, et qu'il a marqué dans son livre les positions des étoiles fixes pour la première année d'ANTONIN, c'est à dire l'an 886 de NABONASSAR. L'intervalle entre l'observation de MÉNÉLAUS et l'époque de

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* *Histoire des Mathématiques*, vol i. p 264

† *Uranologion*, p 262 VI

‡ *Traité des Instruments Astronomiques des Arabes*, p. 4

§ *Hist de l'Astronomie, Moy. Age*, p 448

‖ STADIUS, *Tabulæ Bergenses, Coloniæ Agrippinæ* 1560, p 187

¶ *Memoirs Royal Astronomical Society*, vol. xiii.

** AL-SÛFI (SCHJELLERUP), *Description des Étoiles Fixes*, St. Pétersbourg, 1874, p. 42

Ptolemée est donc de quarante et un ans." Further on he says —"Si nous en retranchons 25′, l'addition faite par Ptolemée à chaque étoile," &c

On this point Delambre remarks.* "We do not see, either in Stadius or Ptolemy, that the Catalogue of Ptolemy was that of Millæus or Menelaus, reduced by the addition of 25′ to all the longitudes. Riccius, who tells us this story, took it from an Arabian author that I have not been able to identify"

There can be little doubt that the Arabian author cited by Riccius, and unknown to Delambre was Abd-Al-Rahman Al-Sûfi

The following passage in Albategnius (*De Scientia Stellarum*, Norimberg, 1537, p 79) bears upon this question —

"Ipsarum autem loca secundum longum et latum in Ptolemæi libro anno primo regis Antonini, qui est annus 886 a rege Nabuchodonosor invenimus in una illarum observationum per quas Ptolemæus opeartus (sic) est fuit observatio Menelai, qua usus est anno 842 à Nabuchodonosor rege"

The Epoch of Menelaus is here given three years earlier than by Al-Sûfi But the general accuracy of Albategnius, or Al-Battani, is severely questioned by Al-Sûfi, who says:† "When Al-Battani wishes to make us believe that he knows the mansions of the Moon and the stars according to the method of the Arabs, and occupies himself with matters foreign to his subject, he only displays his ignorance"

We are subsequently told by Al-Sûfi, that the Epoch of his Catalogue is the year 1276 of Alexander (which corresponds to the beginning of the year A D 964), and that this was 866 years after the observation of Menelaus The year 886 of Nabonassar began July 20, A D 138. The Epoch, therefore, of Ptolemy, according to Al-Sûfi, is A D 138 Lalande‡ gives the first year of Antoninus as the 885th of Nabonassar = July 20, A D. 137, but the researches of Lepsius and Delambre seem to have definitely settled the correct Epoch of Ptolemy's Catalogue to be A D 138

5 Bode, in his *Beobachtung und Beschreibung der Gestirne*, has investigated the question of the Epoch of Ptolemy's Catalogue of Stars, and, on

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* *Hist de l'Ast Moy Age*, p 449

† Al-Sûfi (Schjellerup), p 37

‡ *Mémoires de l'Academie des Sciences*, Paris, 1766, p 466

the assumption that it was reduced from HIPPARCHUS with an erroneous Precessional Constant, he assigned the year A D 63 as the more correct Epoch of the Longitudes in the *Almagest*

After the period of PTOLEMY a long gap of six centuries ensued, during which we have no record of Astronomical Observations at all, with the exception of a few unimportant ones by THIUS, of Athens, A D. 500 *

Our knowledge of Arabian Astronomy, which began to rise in the latter part of the 8th Century, is by no means so complete as it should be Several libraries in Europe are remarkably rich in Arabic and Persian MSS which are still untranslated In the year 1684, Dr EDWARD BERNARD, the Savilian Professor at Oxford, wrote as follows, in a letter published in the Philosophical Transactions for that year·—†

" The Astronomy of the Orientals is interesting to us for many reasons. for the serenity of the regions where they observed; the size and accuracy of their instruments, such as we can hardly credit; the multitude of observers and chroniclers, ten times greater than among the Greeks and Latins; and for the number of princes who aided Astronomy with their protection and munificence One cannot describe adequately in a letter all that the Arabian Astronomers found to reform in PTOLEMY, and their labours for that purpose: the pains they took to measure time by clepsydras of water, by immense sundials, and—what is more surprising—by pendulum vibrations; likewise the industry and exactness they displayed in conducting such delicate investigations "

In this communication Dr BERNARD called attention to the richness of the University of Oxford ‡ in Arabic and Persian MSS on Astronomy and gave extracts from eleven Oriental Star Catalogues in that collection. From that time it does not appear that more than three of the works quoted have been translated to the improvement of our knowledge of Oriental Astronomy.

6. ALBATEGNIUS, or AL-BATTANI, was the earliest Arabian Astronomer of eminence He observed from A D 877 to 918, and to him we owe the Sabeian Tables, containing a Catalogue of Stars for the Epoch A D 879 A

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* *Penny Cycl*, vol ii p 532

† *Phil Trans*, 1684, p 567

‡ Merton College is said to possess 40 MSS (not 400 MSS, as given by MONTUCLA, *Hist. des Mathém*, vol i p 369)

second edition of his Tables gives the longitudes of stars for the Epoch A D 911 * The book, *De Scientia Stellarum*, of AL-BATTANI was translated by REGIOMONTANUS, from an Arabic work entitled *Zig Sabi* (Sabeian Tables), but it does not include the Catalogue of Stars

8 ALI ABOUL CASSIM made a Catalogue of Stars, but our knowledge of it is confined to Dr BERNARD's extract from the Oxford MSS , giving the places of 20 stars for the Epoch A D 938 I have been unable to separate the identity of this Astronomer from "IBN AL-AALAM," who comes next but one in the Table. IBN JUNIS speaks of "ABOUL CASSIM BEN AMADJOUR" as an Astronomer who lived about his time, and who published some Astronomical Tables; † and CASIRI ‡ mentions a Geometer and Arithmetician of Antioch named "ABUL-CASSEM ALI BEN AHMAD," who died A D 986. Possibly one of these may be the Astronomer quoted by the Savilian Professor

There is considerable difficulty in identifying Oriental names, which is much increased by the want of a uniform system of orthography in translating them

9 The splendid work of Professor SCHJELLERUP, to which reference has already been made, makes us well acquainted with the Catalogue of ABD-AL-RAHMAN AL-SÛFI § This book, entitled *Description of the Fixed Stars*, contains a Catalogue of Stars based upon PTOLEMY, the longitudes of the *Almagest* being increased by a fixed quantity of 12° 42′, to bring them up to the Epoch A.D 964, but all the stars were carefully re-examined by the author, and the magnitudes determined with much greater precision SCHJELLERUP says. "AL-SÛFI has given us a description of the starry heavens superior to his model, which for nine centuries had been without rival, and that the equal of it is only to be found in the *Uranometria Nova* of ARGELANDER || He remarks also that AL-SÛFI gives us PTOLEMY's Catalogue more perfect than we had ever possessed it before.

In his own preface, SCHJELLERUP ¶ discusses and in a great measure dis-

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* CAUSSIN, *Notices et Extraits des MSS de la Bibliothèque du Roi*, vol. vii

† SÉDILLOT, *Prolegomènes des Tables Astronomiques d'Oloug Beg*, 1847, p xlii.

‡ CASIRI, *Bibliotheca Arabico-Hispana Escurialensis*, vol i p 411

§ A translation of AL-SÛFI's Preface is given by CAUSSIN in *Notices et Extraits des MSS*, vol xii In the same volume, at p 239, CAUSSIN states that CAZWINI'S *Book on the Constellations* is merely an extract from AL-SÛFI.

|| *Description des Étoiles Fixes*, p 4

¶ *Ibid.*, p 25.

proves, from internal evidence in Al-Sûfi, the assertion that has been made so repeatedly, on the authority of Ptolemy, that *Sirius* formerly shone as a *Red* Star, whereas at the present day it is unquestionably free from any ruddy colour He does not think it probable that the old copies of the *Almagest* described *Sirius* as "Red," for in comparing Al-Sûfi's designation of stars in his Catalogue with those given by Ptolemy, a perfect accordance is found, which must have originally existed between the oldest Arabic translations of the *Almagest* and the original Greek Moreover the ancient Red colour of *Sirius* becomes more than suspicious, inasmuch as we do not find in Al-Sûfi, in speaking of *Sirius*, any Arabic translation of the word *ὑπόκιῤῥος*, which is used in the later editions of Ptolemy

Humboldt remarks * "Perhaps Sédillot, or other philologists conversant with Arabian and Persian Astronomy, may succeed in discovering in the intervals from El-Battani and El-Fergani to Abdurrahman Sûfi and Ebn Junis, and from Ebn Junis to Nassir Eddin and Ulugh Beigh, some evidence respecting the colour of *Sirius* at that time El-Fergani does not include *Sirius* in the Red Stars he mentions If *Sirius* had then ceased to be a Red Star it would seem strange that El Fergani, who follows Ptolemy throughout, should not have pointed out the change of colour in a star of such note"

Schjellerup remarks that Al-Battani, who was well acquainted with all the Arabic translations of the *Almagest*, mentions only five Red Stars, whilst the Greek *Almagest* gives six.

The following abstract of a passage in Le Gentil's memoir, "*Remarques sur les Étoiles Nébuleuses*,"† is interesting to us as bearing on the Catalogue under consideration Speaking of the discovery of the Nebula in *Andromeda*, by Simon Marius, Dec. 15, 1612, he says, "Bullialdus remarks that M de Thou brought from Holland a MS on a skin of parchment, containing a Catalogue of Fixed Stars, with figures of the Constellations A recent note written on the MS. remarked that to reduce the Catalogue to the time of Alphonsus it would be necessary to add 6° to the longitudes. The Nebula in *Andromeda* was marked in both the Catalogue and the figures The figures of the Constellations gave three representations of *Andromeda*, the first a single figure of a woman, the second a figure of a woman with two fish attached to her girdle, and the third showing the woman with one fish on one foot, and the other fish on the other Comparing the longitudes of stars in the Catalogue with the longitudes of those stars in his time, BULLIALDUS found that the Epoch of the Catalogue must have been about A D 995 or 985, whence it is easy to conclude that the Nebula in *Andromeda* was seen long before SIMON MARIUS Neither BULLIALDUS nor LE GENTIL make any surmise as to the author of this Catalogue

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* *Cosmos Physical Description of Heavens*, p 113

† *Mémoires de l'Académie des Sciences*, 1759, pp 456–459

Now AL-SŪFI's Catalogue is interesting as containing figures of the Constellations, and SCHJELLERUP calls especial attention to the fact that it mentions the Nebula in *Andromeda.* AL-SŪFI represents the Constellation *Andromeda* by three figures, the first a single figure of a woman, the second a woman with two fish attached to her girdle, and the third a woman with a fish across her feet—almost identical with the description by BULLIALDUS of the Holland MS.

LE GENTIL's notice of the passage in BULLIALDUS seems to have escaped the attention of SCHJELLERUP, SÉDILLOT, and other Oriental scholars, but there can be no doubt, first from the Catalogue containing the Nebula in *Andromeda*; secondly the peculiar representations of the Constellation *Andromeda*, and thirdly the Epoch of it—the longitudes being about A D 964—that M. DE THOU's MS was a copy (we are not told in what language) of AL SŪFI

10. IBN AL-AALAM, mentioned by CASIRI* under the name "ALI BEN ALHASSAN ABUL CASSEM ALIDA, *vulgo* EBN LALAM," was a renowned Astronomer, who constructed some Astronomical Tables, of which SÉDILLOT says we possess only the Title † His Catalogue of Stars is, however, quoted by Dr BERNARD from an Oxford MS, and given for the Epoch A D. 980 IBN AL-AALAM determined the amount of Precession with particular care, and stated it to be 51″·4 annually, and he was much praised by his successor, IBN JUNIS, for the exactness of his observations, which he made with instruments of his own construction

11 IBN JUNIS, one of the most celebrated Arabian Astronomers,

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* *Bibliotheca Arabico-Hispana Escurialensis*, vol 1 p 411

† *Prolegomènes des Tables Astronomiques d'Olouq Beg*, 1847, p xlii

constructed some Tables from original observations during the reign of the Caliph Hakem, A.D. 996 to 1021, hence called "The Hakemite Tables" They contain a Catalogue of Stars which we gather from Dr BERNARD were reduced to the Epoch A D 996. In 1804 M CAUSSIN examined the Leyden MS of IBN JUNIS. The Hakemite Tables consisted altogether of 81 chapters, of which only 22 are to be found in the Leyden MS. CAUSSIN translated *in extenso* chapters 4, 5, and 6,* which treat of "Eclipses," "Conjunctions of the Planets," and "Motions of the Planets," and gave the titles only of the remaining chapters, published in vol 7 of the *Notices et Extraits des MSS. de la Bibliothèque du Roi* The remaining chapters of these Tables were subsequently translated by SÉDILLOT, who submitted his MS. to DELAMBRE to use in his *History of Astronomy*, but I cannot ascertain whether SÉDILLOT's translation was ever published The value attached to these Tables was proved by later Astronomers, NASSIR EDDIN and ULUGH BEIGH having derived their Tables from them † LAPLACE also used them in his discussion of the Obliquity of the Ecliptic and the greater Inequalities of *Jupiter* and *Saturn*

The date of the last observation in them is Nov. 7, A D 1007 ‡

13. ARZACHEL, we are told, was a Spanish Moor who lived A.D 1080, and was the author of the "Toledo Tables" (*Tabulæ Toletanæ*).

I have examined four MSS. of the 13th and 14th centuries, which purport to be copies of the *Tabulæ Toletanæ*—three of them at the British Museum, and the remaining one in the Library of the Royal Astronomical Society From DELAMBRE's description, they agree with the two MSS. of these Tables which he examined in the Paris "Bibliothèque du Roi."

They contain a Catalogue of 35 Stars (obviously reduced from PTOLEMY, the latitudes being identical), giving Longitudes, Latitudes, Declinations, and Right Ascensions for the Epoch "Ann. Arabum 577 = Anno Christi 1181, mens 4 die 5," this date being given in all the MSS.

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* *Notices et Extraits des MSS*, vol vii p 238 The statement in the *Encyclopædia Britannica*, 9th ed, art "Astronomy," p 751, leads one erroneously to suppose that CAUSSIN translated the whole of the Hakemite Tables

† SÉDILLOT, *Prolegomènes*, 1853

‡ It is doubtful whether an original copy of all these Tables is in existence. The chapters of which the Leyden MS was deficient, were translated by SÉDILLOT from an abstract of the Tables attributed to IBN SCHATIR, who flourished nearly 500 years later, and may therefore possibly be copied from his Damascus Tables.

If ARZACHEL be really the author of these Tables, and lived A D 1080, it is very singular the Epoch of the Catalogue should be 100 years later. This fact alone would seem to throw some doubt on the authorship, though the MSS generally agree in adopting the title *Canones Arzachelis* M. L A SÉDILLOT says,* "Quant à ARZACHEL, on lui attribue *à tort* les Tables Toledanes" He gives no authority for this statement, but the fact I have mentioned with regard to the Epoch supports his opinion.

On the other hand, we have the Alfonsine Tables, constructed at Toledo, and containing PTOLEMY's Catalogue reduced to A D 1252, the longitudes of which are 2° 1′ more than those of the Toledo Tables of Epoch 1181. This would give an annual Precession of 103″, which is quite out of the question. But in investigating the Alfonsine Tables, I find the longitudes of the *Almagest* have been increased by a fixed annual Precessional Constant of 55″ 3, which is likewise the identical quantity employed by the Persian Astronomer AL-SÛFI in reducing PTOLEMY's Catalogue to his Epoch A D 964.

Adopting this Constant for ARZACHEL's Catalogue, we arrive at the Epoch A D 1121 for the longitudes given in the *Tabulæ Toletanæ*, and the difference then of 2° 1′ between these longitudes and those of the Alfonsine Tables is exactly what it should be on this hypothesis ; ex gr.

ALDEBARAN

Long. PTOLEMY, Epoch 137†	Long *Tabulæ Toletanæ*	Long. Alfonsine Tables, Epoch 1252
$1^s\ 12^\circ\ 40'$	$1^s\ 27^\circ\ 47'$	$1^s\ 29^\circ\ 48'$

Difference Long PTOLEMY and *Tabulæ Toletanæ* $= 15^\circ\ 7' - 55''\ 3 = 984$

Difference Long *Tabulæ Toletanæ* and Alfonsine Tables $= 2^\circ\ 1' - 55''\ 3 = 131$

Difference Epoch PTOLEMY, 137, and Alfonsine Tables, 1252 $= 1115$

. Epoch *Tabulæ Toletanæ* $= 137 + 984 =$ A D 1121

Therefore, from the examination of these MSS. we are led to the conclusion that the Epoch of ARZACHEL's Toledo Tables is Anno Arabum 514 = Anno Christi 1121, and, consequently, it is probable they were constructed by him, and further, as far as this evidence goes, SÉDILLOT is in error

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* *Matériaux pour servir à l'Histoire comparée des Sciences Mathématiques chez les Grecs et les Orientaux*, Paris, 1845, p 78

† This Epoch would seem to be that generally adopted for PTOLEMY's Catalogue up to the commencement of the present century

12. BULLIALDUS, at the end of his *Astronomia Philolaica*, gives a Catalogue of the Longitudes and Latitudes of 25 Stars for the Epoch A.D. 1115, translated by a Greek physician named GEORGE CHRYSOCOCCA, from some Persian Tables.* The places are from PTOLEMY, reduced to the Epoch given.

These Tables appear to have been anonymous, for neither CHRYSOCOCCA, TYCHO BRAHE, nor BULLIALDUS mention the author's name, who was also unknown to DELAMBRE. SÉDILLOT gives† "COTHB-EDDIN SCHIRAZI" as "the anonymous Persian author of CHRYSOCOCCA," but does not mention his authority.‡ There would seem to be some doubt on this point, for we find in D'HERBELOT § a disciple of NASSIR-EDDIN named "COTHB-EDDIN MAHMOUD SCHIRAZI," who wrote many books—among others, one on the *Astronomy of the Sphere*—who died A.D. 1311, or nearly 200 years after the Epoch of CHRYSOCOCCA's author. The British Museum possesses at least four Astronomical MSS. by "KUTB-AL-DIN AL SHIRAZI," who died in the year 710 of the Hegira, A.D. 1311. SHERBURNE says || CHRYSOCOCCA lived about A.D. 1240.

14. NASSIR-EDDIN AL-TUSI began to build the Observatory at Meragha A.D. 1259, where he constructed the *Ilkhanic Tables*, which were published A.D. 1270. His Tables are divided into four books, the last of which treats of the Fixed Stars, and gives a Catalogue of the Longitudes and Latitudes of certain Stars. Dr. BERNARD in the paper previously cited, gives a brief extract from the MSS. of NASSIR-EDDIN's Tables at Oxford, reduced to the Epoch A.D. 1233. The Observatory was built about A.D. 1259, and the Tables were published in A.D. 1270; consequently, as the observations were made between those periods, it is difficult to understand how the Epoch of the Catalogue can be of a prior date, A.D. 1233. M. JOURDAIN's Memoir on the Observatory at Meragha does not throw any light on this point.

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* DELAMBRE gives this Catalogue in his *Histoire de l'Astronomie Moy. Age*, but two of the latitudes differ from BULLIALDUS. See, further on, note to Star 3, ABOUL HHASSAN's Catalogue of 240 Stars.

† *Prolegomènes des Tables Astronomiques d'Oloug Beg*, Paris, 1853, p. 289.

‡ "In 1645, Bullialdus published at Paris, from a MS. in the *Bibliothèque du Roi*, an extract from the Tables of CHRYSOCOCCA as a production of Persian astronomy. He was far from suspecting that these Tables were those of EBN JUNIS, constructed at Cairo in 1000, and reduced to the meridian of Tovin in 1079 to serve for a new Persian Calendar of Gemal-Eddin Melik-Schah." SÉDILLOT, *Matériaux*, p. 80.

§ *Bibliothèque Orientale*, Paris, 1697, p. 788.

|| *The Sphere of Marcus Manilius, with Annotations*, by E. SHERBURNE, London, 1675, p. 32.

17. ABD-AL-JALIL AL-SIJAZI made a Catalogue of Stars for the Epoch A D 1261, as we know from Dr. BERNARD's extracts; but he does not appear to have been well known as an Astronomer, and his works have remained untranslated

18 Of ABOUL HHASSAN, whose proper name is "ABOUL HHASSAN ALI, of Morocco," we possess a very valuable *Treatise on the Astronomical Instruments of the Arabs,* which has been most ably translated by M J J. SÉDILLOT This work contains three Catalogues of Stars possessing a good deal of interest

The first is a Catalogue of the Longitudes and Latitudes of 240 Stars reduced to the Epoch of the beginning of the Hegira, July 15, A D 622 The second gives the Declinations of 180 Stars, and the third the Co-ascendants of 210 Stars, both for the Epoch A D 1282 Unfortunately the author gives us no idea how these Catalogues were made, moreover, there is considerable doubt as to the period when ABOUL HHASSAN published them SÉDILLOT says * "If he did so in 1282, it is strange he makes no mention of the Alfonsine Tables, which appeared in 1252 He gives the obliquity of the Ecliptic as 23° 36′ for the year 680 Hegira, A.D 1282, but in another passage he says positively that in his time the obliquity was only 23° 35′ This difference 1′ = 53 Arabic years, would tell us that he wrote about 627 Hegira = A D 1230" †

SÉDILLOT gives merely a translation of these Catalogues without note or comment, and says that he was unable to identify the stars by comparison with a modern atlas This work I have endeavoured to supply, and from careful examination and comparison of the Catalogues, have identified every star contained therein.

The first Catalogue of the Longitudes and Latitudes of 240 Stars contains all the stars in the other two. There is no doubt that the places have been simply reduced from PTOLEMY to the Epoch of the beginning of the Hegira DELAMBRE, in speaking of it, remarks ‡ "It has seemed to us too inexact to be reproduced, the most ordinary errors are more than one degree It contains some southern stars which are not to be found in PTOLEMY."

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* *Traité des Instruments Astronomiques des Arabes*, Paris, 1834, p 13

† A convenient rule for converting years of the Hegira to the Christian Era, is to multiply the year of the Hegira by 0 970203 and add 622 54, the result gives the year and fraction of the year Anno Domini (Old Style).

‡ *Histoire de l'Astronomie, Moy Age*, p 187.

Neither of these statements can I confirm. Every star I have identified in PTOLEMY, either in AL-SÛFI, or BAILY's compiled edition in the 13th vol. of the *Memoirs of the Royal Astronomical Society*.

This Catalogue contains several errors which are very interesting and instructive, as tending to throw light upon discrepancies and mistakes which have been discovered in ancient Catalogues. I have therefore incorporated the Catalogue with this paper, appending to each star the common designation of BAYER or FLAMSTEED, and subjoining notes of the errors I have detected.

It is by no means improbable that one who wrote so valuable a treatise on Astronomical Instruments and Calculations, should have made original observations, and consequently it is possible the Catalogue of the Declinations of 180 Stars may have been constructed from observations. In order to show the amount of accuracy it possesses, I have compared ABOUL HHASSAN's Declinations of 36 Principal Stars with the Greenwich 7-year Catalogue reduced to the Epoch 1282.

Star	Declination ABOUL HHASSAN	Declination Gr 7 year Cat	Difference
	° ′	° ′	° ′
α Hydræ	− 3 31	− 5 43	+ 2 12
α Aquarii	− 3 46	− 3 41	− 5
α Orionis	+ 6 6	+ 6 59	− 53
α Canis Minoris	+ 6 40	+ 6 49	− 9
α Aquilæ	+ 6 46	+ 7 12	− 26
α Virginis	− 6 48	− 7 19	+ 31
β Orionis	− 9 42	− 9 17	− 25
α Pegasi	+11 17	+11 24	− 7
α Libræ	−12 15	−12 52	+ 37
α Ophiuchi	+13 13	+13 20	− 7
α Capricorni	−14 20	−14 31	+ 11
α Tauri	+14 53	+14 47	+ 6
γ Arietis	+15 35	+15 38	− 3
α Leonis	+15 36	+15 20	+ 16
α Canis Majoris	−15 38	−15 58	+ 20
α Herculis	+15 54	+15 27	+ 27

Star	Declination Aboul Hhassan	Declination Gr 7 year Cat	Difference
	° ′	° ′	° ′
β Leonis	+18 40	+18 34	+ 6
α Arietis	+19 33	+19 55	− 22
γ Leonis	+23 36	+23 21	+ 15
α Bootis	+23 48	+23 3	+ 45
α Andromedæ	+25 4	+24 57	+ 7
β Cygni	+26 48	+26 39	+ 9
β Tauri	+27 13	+27 40	− 27
β Geminorum	+29 0	+29 28	− 28
α Coronæ	+29 52	+29 19	+ 33
α Geminorum	+32 55	+33 8	− 13
α Piscis Australis	−35* 31	−33 20	− 2 11
α Lyræ	+38 27	+38 18	+ 9
γ Andromedæ	+38 32	+38 44	− 12
12 Canum Venaticorum	+42 16	+42 16	0
α Cygni	+42 44	+42 51	− 7
α Aurigæ	+44 25	+44 53	− 28
α Persei	+46 34	+47 1	− 27
α Cassiopeiæ	+52 13	+52 33	− 20
α Ursæ Majoris	+65 35	+65 33	+ 2
β Ursæ Minoris	+77 2	+77 6	− 4

As Aboul Hhassan's second Catalogue is the earliest extensive Catalogue of Declinations, so the third is the most ancient Catalogue of Right Ascensions, or Co-ascendants of Stars—the Right Ascensions being reckoned from the Solstitial Colure, the First Point of *Capricornus*.

Nos 22 and 24 we know of only from the extracts given by Dr Bernard in the *Phil Trans* 1684 I have altogether failed in obtaining further knowledge of these Catalogues

23 Gassendi gives, in a letter at the end of vol. 4 of his works, a Catalogue of 47 Stars from the Arnaldin Codex for the Epoch 1364 The latitudes are taken from Ptolemy.

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* *Vide* Note to Star No 30, Aboul Hhassan's Catalogue of 240 Stars

† *Opera Omnia*, Lugduni 1658, tom iv p 534, also in *Riccioli Astronomiæ Reformatæ*, tom i p 216

25. Ulugh Beigh was the greatest of the Oriental Astronomers, and is therefore the best known to us. His Catalogue of Stars was based upon that of Abd-Al-Rahman Al-Sûfi (they both contain the same 1018 stars and one duplicate), but there is no doubt it was the result of new and original observations.

Ulugh Beigh remarks, in the Preface to his Tables [*] "We have re-observed all the stars already determined, with the exception of 27 which are not visible at the latitude of Samarcand—namely, the seven in *Ara*, eight in *Navis* (Nos. 36 to 41, 44 and 45), eleven in *Centaurus* (Nos. 27 to the end), and one (No. 10) in *Lupus*; and we have taken these 27 stars from the book of Abderrahman Soufi, bearing in mind the difference of Epoch of his Catalogue and ours.

"Besides these, there are eight stars mentioned by Abderrahman Soufi in his book, as being given by Ptolemy, but which Abderrahman did not see, and which, in spite of all our researches, we have failed to discover. On this account we have not given these stars in the present Catalogue These stars of Ptolemy are the 14th of the Herdsman (*Auriga*), the 11th of the Wolf, and the six external stars of the Southern Fish.

"We have given in our Catalogue the places of stars for the commencement of the year 841 of the Hegira, so that for any future time we can ascertain the places of any stars on the supposition that they advance one degree in seventy solar years."

Ulugh Beigh, like Nassir Eddin and Cothb-Eddin Schirazi, adopted the Precessional Constant as determined by Ibn-Al-Aalam, viz. 51″ 4. His Tables were based upon the Hakemite Tables of Ibn Junis, and were prepared mainly by his Astronomers, Ali Cushi and Ali ben Gaiat [†]

The question has been discussed whether Ulugh Beigh wrote his works in Turkish, Arabic, or Persian. Sédillot says "no mention has ever been made of a copy of the Tables in Oriental Turkish. We possess two copies in Arabic which present no table differences, and are evidently the work of two translators unknown to each other. On the other hand, the Persian MSS. show a perfect accordance,"—which induces Sédillot to believe they were written originally in that language.[‡]

26. Cardinal Nicholas, of Cusa, was an original observer, and made a Catalogue of the Longitudes and Latitudes of Stars from his own observations.

[*] L A. Sédillot, *Prolegomènes des Tables Astronomiques d'Oloug Beg*, Paris, 1853, p 198.

[†] Sédillot, *Prolegomènes*, 1853, p 289.

Ibid, 1847, p cxxxvii.

Riccioli[*] gives an extract from this Catalogue reduced to the Epoch A D 1440.

27 Ala Eddin Ibn Shatir published a Catalogue of Stars for the Epoch A D. 1480, in his "Damascus Tables," which were derived from those of Ibn Junis

29. Mohammed ben Abou-Bekre Al-Tizini is known from Thomas Hyde having given a Catalogue of 300 Stars by him in his translation of Ulugh Beigh. A curious error has in consequence crept into the works of Humboldt and Arago. It is therein stated: "Ulugh Beigh's Catalogue contained at first only 1019 positions of stars reduced to the year A D 1437 A later commentary furnishes 300 additional stars observed by Abu-Bekri Altizini in 1533"[†]

This Catalogue is printed at the end of Hyde's *Commentary* on Ulugh Beigh, and gives the Right Ascensions and Declinations of 302 Stars for the Epoch 1534, all of which are to be found in Ulugh Beigh's Catalogue of 1019 Stars. Therefore it is certainly neither additional to, nor a commentary on Ulugh Beigh The Right Ascensions are reckoned from the First Point of *Capricornus*, the Solstitial Colure, as we find in most of the ancient Catalogues giving this Co-ordinate We have no information how the Catalogue was formed. To test its accuracy I have compared the Declinations of 20 stars with the Greenwich 12-year Catalogue reduced to the Epoch 1534

Star.	Declination Al-Tizini		Declination Gr 12-year Cat		Difference.
	°	′	°	′	′
α Aquarii	− 2	21	− 2	36	−15
α Canis Minoris	+ 6	5	+ 6	26	−21
α Aquilæ	+ 7	24	+ 7	37	−13
α Virginis	− 8	29	− 8	44	−15
β Orionis	− 9	13	− 8	43	+30
α Ophiuchi	+13	9	+12	53	+16
α Leonis	+14	8	+14	15	− 7
α Tauri	+15	43	+15	35	+ 8

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[*] *Astronomiæ Reformatæ*, tom 1 p 217 The work cited by Riccioli is, we presume, the following one, mentioned in the Catalogue of the Poulkova Library "Cusa (de) N, *Opera*, 2 vol fol (*sine loco et anno*)—*Liber anno* 1480 *anterior habendus est*" The British Museum contains the more recent Basil edition of 1565 On which, see *Appendix*

[†] This date is a mistake The Epoch given by Hyde is "pro *fine* anni Hegiræ purissimæ 940, i Chr 1533" (?) The year 940 Hegira began July 23, A D 1533, and ended July 12, A D 1534, consequently the Epoch of the Catalogue is A D 1534

Star	Declination Al Tizini		Declination Gr 12 year Cat		Difference
	°	′	°	′	′
α Canis Majoris	−15	50	−16	4	−14
γ Arietis	+17	2	+17	1	+ 1
β Leonis	+17	55	+17	11	+44
α Arietis	+21	9	+21	15	− 6
α Bootis	+22	14	+21	36	+38
β Cygni	+27	31	+26	58	+33
β Tauri	+27	43	+28	14	−31
α Lyræ	+38	37	+38	20	+17
α Cygni	+43	50	+43	37	+13
α Aurigæ	+45	0	+45	32	−32
η Ursæ Majoris	+51	29	+51	38	− 9
β Ursæ Minoris	+76	0	+76	4	− 4

AYEEN AKBERY, who lived A D 1556—1615, has left no Catalogue of Stars, but gives a list of 221 stars which are to be found in the 28 Lunar Mansions He has given the following estimate of the apparent diameters of stars .—

	Diameter
1st Magnitude	7′
2nd „	6′
3rd „	5′
4th „	4′
5th „	3′
6th „	2′
7th „	1′

It is curious he should have classified the visible stars into *seven* magnitudes, which was not suggested by any preceding Astronomer

33 WILLIAM THE 4TH, Landgrave of Hesse, was the founder of an Observatory, and constructed a Catalogue of Stars from original observations, of which we possess only a portion The Catalogue known as that of the Landgrave of Hesse consists of 368 stars, and was published by FLAMSTEED in the 3rd volume of the *Historia Cœlestis*, and by HEVELIUS in his *Prodomus Astronomiæ.* But we learn* that during the French occupation of

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* *Histoire de l'Académie*, 1761, p. 130

Cassel, the Duke of Laval, at the request of the Abbé de LACAILLE, searched the Library of the Palace, and made a copy of the MS observations of the Landgrave WILLIAM which were deposited there LACAILLE, in his report on these MSS., says that most of the observations made by WILLIAM THE 4TH and his assistants, CHRISTOPHER ROTHMANN, Astronomer, and JUSTUS BYRGIUS, Mechanic, were devoted to making an exact Catalogue of the Principal Stars visible in his latitude He succeeded in determining the longitudes, latitudes, and magnitudes of more than 900 stars, all observed directly and by different methods The MSS were found to contain not only this Catalogue, but likewise the observations themselves, with the details of his methods and the description of his instruments

In the second volume of TYCHO BRAHE'S *Historia Cœlestis* we have a Catalogue of 1,034 Stars, constructed from the Hessian observations and reduced to the Epoch 1594 This was made at a period when the Tychonic observations were interrupted, upon which TYCHO remarks· "Eum hiatum ut expleremus suffectæ sunt Tichonicis observationes Hassiacæ, et Catalogus fixarum ab Illustrissimo GUILIELMO Hassiæ Langravio pulcherrimo supra fidem ordine eruditis vigiliis opera ROTHMANNI Mathematici aut si mavis Iusti (Justi) Burgii paratus atque digestus"

47 In 1632 PHILIP LANSBERG published his *Tabulæ Motuum Cœlestium perpetuæ*, Middelburgi Zelandiæ, 1632. At page 102 is given a Catalogue of the Longitudes, Latitudes, and Right Ascensions of 25 Stars, said to be determined from his own observations, and reduced to the beginning of the Christian era, A D. 1

On comparing LANSBERG'S latitudes of stars with the three Catalogues of PTOLEMY, ULUGH BEIGH, and TYCHO BRAHE, they do not prove to be identical with either of them, but they approximate to PTOLEMY more nearly than to the others Comparing the differences in longitude of 14 pairs of stars, nine are identical with or very closely approximate to TYCHO'S LANSBERG assumes the Right Ascension of γ *Arietis* at the Epoch A D 1 to be 0° 0′, and longitude, *Aries* 4° 25′, then, strangely enough, he makes differences of the Right Ascensions of Stars equal to their differences of longitude

The Catalogue is probably correctly stated to be original, though we have no information how it was constructed.*

48. The Catalogue known as that of JACOB BARTSCH, consists of 136 southern stars, reduced by a seaman named PETER THEODORE, from the

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* DELAMBRE omits all notice of LANSBERG in his *History of Astronomy*

observations of certain navigators made at various ports in the Southern Hemisphere. It is interesting to us as being the earliest Catalogue of Southern Stars, and also as having led to the formation of certain Southern Constellations now generally accepted The places are of course only roughly approximate, and the incorrectness of it was so great as to induce Edmund Halley to go out to St Helena and make the accurate Catalogue which bears his name, and which has been fully described by Mr Baily in his edition of it

61. Father Noel's Catalogue of 225 Southern Stars was made during the Jesuit College expedition to China and the Indies at the latter part of the 17th century It was in order of date, the third Catalogue of Southern Stars made, but the places are very inaccurate.

The preceding Catalogue, No 60, was probably constructed by some members of the same expedition.

71 Riccioli's General Catalogue* of 1,450 Stars for the Epoch 1701 ("ad annum Christi completum 1700") consists of stars arranged according to Constellations and subdivided into four classes.

The 1st class contains 110 stars observed by Riccioli and Grimaldi, and includes the *Pleiades* observed by Vincentio Mutus and Michael Langrenus

The 2nd class consists of 958 stars from the Rudolphine Tables

The 3rd class consists of 246 stars observed by Hipparchus and Ptolemy, but not by Riccioli or Tycho.

The 4th class contains 136 stars in Southern Constellations observed only by certain navigators (Bartsch's Catalogue).

85 The Catalogue of Joannes Jacobus Marinonius consists of the Right Ascensions of 218 stars arranged in the form of Differences of R A by Transit from eight fundamental stars, with their observed altitudes above the horizon of Vienna.

From α Arietis to α Aurigæ	19 Stars
α Aurigæ to α Canis Majoris	22 "
α Canis Majoris to α Leonis	23 "
α Leonis to α Bootis	31 "
α Bootis to α Scorpii	30 "
α Scorpii to α Lyræ	22 "
α Lyræ to α Piscis Australis	44 "
α Piscis Australis to α Arietis	27 "

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* *Astronomiæ Reformatæ*, Bononiæ, 1665, tom i. p 265

108 LACAILLE's Catalogue of 515 Zodiacal Stars is a fragment of a larger Catalogue of 800 Stars which he had intended making, but was prevented by death from carrying out The observations were made in 1760 and 1761, and were reduced by M BAILLY to the Epoch 1765

355 SANTINI's Zone Catalogue for 1840 consists of stars to the 9th magnitude, in zones of 2° between the parallels +11° and −11° of Declination The following are the numbers of stars in each zone —

Zone	−1°	to	+1°	=	276	Stars	Zone	−1°	to	−3°	=	438	Stars
	+1	to	+3	=	286	,,		−3	to	−5	=	479	,,
	+3	to	+5	=	271	,,		−5	to	−7	=	454	,,
	+5	to	+7	=	274	,,		−7	to	−9	=	474	,,
	+7	to	+9	=	312	,,		−9	to	−11	=	503	,,
	+9	to	+11	=	325	,,							

The other Catalogues are briefly explained in the notes appended to them

The Table of Star Catalogues has eight columns —

1 The number of the Catalogue in order of Epoch

2 The name of the Catalogue, which in almost all cases is the name of the Astronomer who constructed it

3 The date of publication (printed)

4 The number of stars in the Catalogue

5 Brief information as to the magnitudes or special peculiarities of the stars

6 Particulars of the positions of stars and the co-ordinates given in each Catalogue, whether Longitudes, Latitudes, Right Ascensions, Declinations, or Special Zones

7 The Epoch, which is the basis of the arrangement adopted

8 Notes on the Catalogues, with references to the works in which they are to be found

London, January 1876

Table of Star Catalogues.

No	Name	Date Published.	Number of Stars	Description of Stars.	Mean Places, Co-ordinates	Epoch	Notes
1	Eudoxus		47	Prin Stars	Declinations	B C 368 to 352	Tycho Brahe, "Historia Cœlestis, Augustæ Vindelicorum, 1666," tom i p vii Extracted from the Astronomical Poem of Aratus
2	Aristillus and Timocharis		18	Prin Stars	Declinations	283	In Ptolemy, "Almagest" (Halma), vol ii p 16
3	*Hipparchus		1,080	Visible Stars	Long, Lat ?	128 ?	Achilles Tatius, 'Ad Arati Phœnomena qui liber falso Eratostheni tribuitur" Stellas omnes Hipparchus asserit esse 1080 quæ nimirum constellationes apparentes efficiunt" Petavius, 'Uranologion, Lutetiæ Parisiorum, 1630" p 262, vi
4	*Menelaus					A D 97	Catalogue said to be made from Hipparchus (Sedillot)
5	Ptolemy, Claudius †	1515 L 1528 T. 1538 G 1712 O 1786 M 1816 H 1843 B	1,025	Visible Stars	Long, Lat	138	Catalogue contained in Books 7 and 8 of the "Almagest' The principal editions are two Venice editions, in *Latin*, by Liechtenstein (L) and Trapezuntius (T), and the following in *Greek* Basil, Grynæus (G), Oxford, Halley (O), in Hudson's "Geographia" Montignot (M), Halma (H), and Baily's compiled edition (B), in vol xiii of the "Memoirs of the Royal Astronomical Society'
	Ptolemy (Bode) See No 182						
6	* Albategnius				Long, Lat	879	In the Sabeian Tables, 1st edition
7	* Albategnius				Long, Lat	911	In the Sabeian Tables, 2nd edition
8	Ali Aboul Cassim		20	Prin Stars	Long, Lat.	938	Given by Dr Bernard, from an Oxford MS, in Phil Trans," 1684, p 567 Places reduced from Ptolemy
9	Abd-Al-Rahman Al-Sûfi (Schjellerup)	1874	1,018	Visible Stars	Long, Lat.	964	"Description des Étoiles fixes par l'Astronome Persan Abd-Al-Rahman Al-Sûfi ' Translated by Prof Schjellerup, from the Copenhagen and St Petersburg MSS ' St.-Petersbourg, 1874' Places from Ptolemy, star magnitudes newly determined.
10	Ibn Al-Aalam		19	Prin Stars	Long, Lat.	980	Given by Dr Bernard, in his extracts from the Oxford MSS Phil Trans," 1684. Places from Ptolemy
11	Ibn-Junis		18	Prin. Stars	Long, Lat.	996	From the Hakemite Tables Dr Bernard's extracts, Oxford MSS, 'Phil Trans," 1684 Ptolemy's latitudes

† Translations and reductions of Ptolemy's Catalogue will be found also in the works of Abraham Zacutus, Schöner, Copernicus Flamsteed, Delambre, and others, but they have not been inserted in the Table

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places Co ordinates	Epoch	Notes
12	Cothb-Eddin Schirazi		25	Prin Stars	Long , Lat	A D 1115	The Persian Tables given by Chrysococca anonymously (published by Bullialdus, ' Astronomia Philolaica ") are attributed by Sedillot to this author Ptolemy's places reduced to the Epoch 1115
13	Arzachel		35	Prin Stars	Long , R A , Lat , & Dec	1121	' Tabulæ Toletanæ " (British Museum, Harleian MSS 13 and 3,647) Ptolemy's places reduced to epoch
14	Nassir-Eddin Al-Tusi		23	Prin Stars	Long , Lat	1233	From the Ilkhanic Tables Bernard's extract from Oxford MSS , " Phil Trans ," 1684 Ptolemy's latitudes
15	Alfonsine Tables .	1492	1,022	Visible Stars	Long , Lat	1252 4	" Tabule Tabularum Celestium Motuum Divi Alfonsi Regis Romanorum et Castelle Illustrissimi, Venetiis 1492 ' Ptolemy's Catalogue reduced to the Epoch 1251 years and 5 months The first printed edition
16	Alfonsine Tables .	1518	1,022	Visible Stars	Long , Lat	1252 4	" Tabule Astronomici Divi Alfonsi Regis Romanorum et Castelle, Liechtenstein Venetiis 1518 " 2nd edition
17	Abd-Al Jalil .		22	Prin Stars	Long , Lat	1261	" Phil Trans ," 1684. Dr. Bernard's extract from Oxford MSS Ptolemy's latitudes
18	Aboul Hhassan Ali (J J Sédillot)	1834	240	Visible Stars	Long , Lat	pro 622 5	" Table des Longitudes et Latitudes de 240 Étoiles pour le commencement de l'Hégire (jeudi, 15 Juillet à midi, 622 de J -C) " " Traité des Instruments astronomiques des Arabes (Sedillot), Paris, 1834," p 140
19	Aboul Hhassan Ali (J J Sédillot)	1834	180	Visible Stars	Declinations	1282	" Table de la Déclinaison de 180 Étoiles pour la fin de l'annee 680 de l Hegire ' ' Traité des Inst Ast ," p 191
20	Aboul Hhassan Ali (J J Sédillot)	1834	210	Visible Stars	Co ascendants	1282	" Table des Co-ascendants dans la Sphère droite de 210 Étoiles fixes, a partir de 0° 0′ du *Capricorne*, pour la fin de l'an 680 de l'Hegire " " Traité des Inst. Ast ," p 276.
21	Sacrobosco	1581	77	Visible Stars	Long , Lat , R A , Decl		' Speculum Astrologici," p 674 Ptolemy's latitudes
22	Persian Tables (Pembroke).	.	16	Visible Stars	Long , Lat	1346	' Phil Trans , ' 1684, Dr Bernard s extracts, Oxford MSS Ptolemy s latitudes
23	Arnaldin Codex		47	Visible Stars	Long , Lat	1364	" Gassendi Opera Omnia, Lugduni 1658, ' tom iv p 534 Quoted in a letter from Gassendi to Wendelinus, July 1636 Ptolemy's latitudes
24	Shehabeddin of Aleppo		23	Visible Stars	R.A , Decl	1436	Presumably from a later edition of the Ilkhanic Tables, " Phil Trans , ' 1684, Dr Bernard's extracts, Oxf MSS

25	Ulugh Beigh	1665 H 1843 B	1,018	Visible Stars	Long, Lat	1437	"Tabulæ long ac lat Stellarum Fixarum ex observatione Ulugh Beighi, Tamerlanis Magni Nepotis, Oxonii 1665" Made from original observations at Samarcand. Trans by Thos Hyde, 1665 New ed by F Baily "Ast Soc Roy Mems," vol xiii
26	Cardinal Nicholas of Cusa		9	1st Mag	Long, Lat	1440	In Riccioli, "Astronomiæ Reformatæ," tom 1 p 217
27	Ala-Eddin Ibn Shatir		22	Prin Stars	Long; R A, Decl	1480	In "The Damascus Tables" Dr Bernard s extracts, Oxford MSS., "Phil Trans," 1684
28	Alfonsine Tables (Gauricus)	1545	1,022	Visible Stars	Long, Lat	1501 0	"Divi Alphonsi Romanorum et Hispaniarum Regis, Astronomicæ Tabulæ in propriam integritatem restitutæ, Parisiis 1545" Ptolemy's Catalogue, reduced by Gauricus from Alfonsine Tables of Epoch 1252 4
29	Mohammed Al-Tizini	1665	302	Prin Stars	R A from 0° 0' *Capricornus*, Decl	1534	"Tabula Stellarum Fixarum secundum motionem Declinationis et Ascensionis, pro fine anni Hegiræ purissimæ 940, 1 Chr 1533" Translated by Hyde, published with his edition of Ulugh Beigh
30	Appianus	1584	1,022	Visible Stars	Long, Lat	1550	"Cosmographia Antverpiæ 1584," p 251 Ptolemy's Catalogue reduced to epoch
31	Stadius	1560	76	Prin Stars	Long, Lat, R A, Decl	1558	"Tabulæ Bergenses," p 215 "Verus ex observatione demonstratus Epilogismus"
32	Tycho Brahe (Schjellerup)	1856	26	Prin Stars	R A, Decl	1580 0	"Tycho Brahe's original Observationer benyttede til Banebestemmelse af Cometen 1580" in "Copenhagen Dansk Vid. Selsk Skrif," vol iv pt 1 p 1 Comparison stars used by Tycho Brahe for determining the place of the Comet of 1580 Positions for Epoch 1580 0 reduced by Schjellerup from modern observations, with corrections for reduction to the mean dates of Tycho's observations
33	William 4th, Landgrave of Hesse	1666	1,034	Visible Stars	Long, Lat	1594 0	In Tycho Brahe, "Historia Cœlestis," vol ii, p 545 reduced from the Hessian observations of the Landgrave of Hesse and Rothmann
34	William 4th, Landgrave of Hesse	1725	368	Visible Stars	Long, Lat	1594 0	Flamsteed, Historia Cœlestis, vol iii
35	*William 4th, Landgrave of Hesse		900	Visible Stars	Long, Lat		In MSS examined by Lacaille, "Hist de l'Acad, 1761," p 130
36	Tycho Brahe	1610	777	Visible Stars	Long, Lat	1601 0	Astronomiæ Instauratæ Progymnasmata, Francofurti, 1610," p 257 From original observations at Uraniberg
37	Tycho Brahe	1610	100	Select Stars	R A, Decl	1601 0 & 1701 0	"Ast Inst Progym" p 276
38	Tycho Brahe	1627	1,005	Visible Stars	Long, Lat	1601 0	In Kepler s "Tabulæ Rudolphinæ' Recent ed by Baily, Ast Soc Roy Mems," vol xiii

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co-ordinates	Epoch	Notes
						A D	
39	Bartsch James	1627	136	Prin Southern Stars	Long, Lat		A Catalogue of Southern Stars, reduced by Peter Theodore from the observations of Amerigo Vespucci and other navigators made in the Southern Hemisphere In Kepler's "Tabulæ Rudolphinæ"
40	Bayer	1603	1,706	Visible Stars	Long, Lat		Stars in Atlas "Uranometria omnium Asterismorum, Augustæ Vindelicorum, 1603"
41	Pagan Comte de	1681	60	1st & 2nd Mags	Long, Lat	1601 0	From Kepler's "Tabulæ Rudolphinæ" In Tables Astronomiques, Paris 1681"
42	Kepler J	1606	47	Visible Stars	Long, Lat	1604 0	Catalogus quarundam Stellarum in Constellationibus Serpentarii, Serpentis et Scorpionis, quæ a Tychone vel etiam a Ptolemæo omissæ sunt In "De Stella Nova in pede Serpentarii, Pragæ, 1606," p 75
43	Grienbergerus, Chr	1679	1,234	Visible Stars		1612	A Catalogue of Stars from Clavius Tycho, and Piffero, with co-ordinates for setting off their places in 25 charts In "Prospectiva Cœlestis Nova Imaginum Cœlestium, Augustæ Vindelicorum, 1679"
44	Origanus, David	1599	401	Visible Stars	R A, Decl	1620 0	"Ephemerides Novæ Annorum 36 incipientes ab anno Christi 1595, Francofurti ad Viadum," p 94
45	Olivetanus Vinc R	1647	231	Prin Stars	Long, Lat	1621 0	Places given according to the Tables of Alfonsus, Copernicus, and Tycho Tabulæ Mediceæ, in "Tabulæ Motuum Cœlestium Universales, Florentinæ, 1647" p 266
46	Schiller, Julius	1627	360	Prin Stars	Long, Lat, R A, & Decl	1625 0	"Tabula Canonica præcipuarum Cœli Stellarum Fixarum" In "Cœlum Stellatum Christianum Augustæ Vindelicorum, 1627," p 131
47	Lansberg, Philip	1632	25	Prin Stars	R A Long, Lat	Pro A D I	'Catalogus XXV Stellarum Fixarum summa cura a nobis observatarum una cum earum Longitudine et Latitudine ad initium annorum Christi" In "Tabulæ Motuum Cœlestium perpetuæ, Middelburgi Zelandiæ, 1632," p 102
48	Bartsch James	1661	1,111	Visible Stars	Long, Lat	1630 0	In 'Planisphærium Stellatum" Norimbergæ, 1661 Includes P Theodore's Southern Stars
49	Argolius Andrea	1659	303	Prin Stars	Long, Lat R A, Decl	1640 0	"Ephemerides ab anno 1640 ad annum 1700, Lugduni, 1659"
50	Riccioli, G B	1651	70	Prin Stars	Long, Lat, R A Decl	1645 0	'Tabula LXX fixarum a nobis observatarum" "Almagestum Novum," vol 1 p 476
51	Riccioli, G B	1665	127	Prin Stars	Declinations	1661 0	"Astronomiæ Reformatæ," tom 1 p 249
52	Riccioli, G B	1665	62	Prin Stars	Right Ascen	1661 0	'Astronomiæ Reformatæ,' tom 1 p 253

53	Riccioli, G B	1665	101	Prin Stars	Long , Lat , R A , Decl	1661 0 & 1701 0	"Astronomiæ Reformatæ," tom i p 260
54	Hevelius, J	1690	1,888	Visible Stars	Long , Lat , R A , Decl	1661 0 & 1701 0	Catalogue consists of 950 stars of the Ancients, 603 newly observed by Hevelius, and 335 of Halley's Southern Catalogue In "Prodomus Astronomiæ, Gedani, 1690," pp 119, 269
55	Hevelius, J	1843	1,564	Visible Stars	Long , Lat , R A , Decl	1661 0	Baily's Ed in 'Ast Soc Roy Mems ," vol xiii
56	Goldmayer, And	1661	1,240	Visible Stars	Long , Lat	1661 0	Catalogue made from the observations of Tycho, Kepler, and Christian Severin In 'Praxis Compendiosa"
57	Levera, Franciscus	1663	387	Visible Stars	Long , Lat	1661 0	Catalogue from Tycho for stars visible in his latitude, and from Ptolemy for stars invisible to Tycho In "Prodomus Universæ Astronomiæ Restitutæ, Romæ, 1663," p 399
58	Levera, Franciscus	1664	380	Visible Stars	R A , Decl	1661 0	"Tabula Declinationum et Ascentionum Rectarum." In 'De Inerrantium Stellarum viribus et excellentia, Romæ, 1664,' p 47
59	Halley, Edmund, Ast Roy	1679	341	Stars to 6 Mag	Long , South Lat	1678 0	Catalogue of Southern Stars, made by Halley at St Helena, in the years 1676 to 1678 In "Catalogus Stellarum Australium ' Recent ed. by Baily in "Ast Soc Roy Mems ,' vol xiii
60	Chinese Catalogue		92	Prin Stars	R A , Decl , Long , Lat	1683	Catalogue of Stars, giving their Chinese names and European synonymes In 'Bentley's Hindu Astronomy," taken from Morrison's Chinese Dictionary
61	Noel, Father	1729	225	Stars to 6 Mag	R A , South Decl	About 1689	Catalogue of Southern Stars made at Macao and Rachol by the Jesuit College Expedition to India and China "Acad des Sciences Mems ," vol vii p 841
62	Noel, Father	1710	352	To 6 Mag	R A , Decl	1688 0	"Observationes Mathematicæ et Physicæ in India et China factæ ab anno 1684 usque ad annum 1708, Prague, 1710," p 44 A Catalogue of all known Southern Stars, observed by the Jesuit College Expedition
63	Flamsteed, J , Ast Roy The British Catalogue	1725	2 934	To 7 Mag	Long , Lat , R A , N P D	1690 0	"Stellarum inerrantium Catalogus Britannicus ad annum Christi completum 1689" From observations made at Greenwich in the years 1689–1719, published in vol ii of Hist Cœlest 'Historia Cœlestis Britannicæ, Londini, 1725,' vol iii
64	Flamsteed, J , Ast Roy	1781	2 919		Long ; Lat , R A , Decl	1690 0	'Atlas Cœlestis, 27 maps, London, 1781"
65	Flamsteed (Baily)	1835	3,310	To 7 Mag	R A., Decl	1690 0	Baily's corrected and enlarged edition of the British Catalogue In An Account of the Rev John Flamsteed, the First Astronomer Royal, London, 1835"

No	Name.	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
66	Flamsteed (Herschel, Caroline)	1798	561		Differences of N P D from Determining Stars	A D 1690 0	"Catalogue of Stars taken from Mr Flamsteed's observations contained in the 2nd vol of the 'Historia Cœlestis,' and not inserted in the British Catalogue' Contains 190 stars of doubtful R A and N P D, all arranged in the order in which they occur in Flamsteed's observations London, 1798
67	Flamsteed (Baily)	1831	564	To 7 Mag	R A, Decl.	1690 0	"Catalogue of the positions (in 1690) of 564 Stars observed by Flamsteed but not inserted in his British Catalogue" In "Ast Soc Roy Mems" vol iv
68	Maraldi, J P	1715	238	Zodiacal Stars	Long, Lat, R A, Decl	1700 0	Catalogue reduced from the observations of Maraldi at the Paris observatory In "Manfredi (Eust) Ephemerides Motuum Cœlestium, Bononiæ, 1715"
69	Maraldi, J P	1715	25	Extra Zodiacal	Long, Lat, R A, Decl	1700 0	
70	Halley (Hevelius)	1690	335	To 6 Mag	Long, Lat	1700 0	Halley's Southern Catalogue reduced to Epoch 1700 by Hevelius In "Prodomus Astronomiæ,' p 309
71	Riccioli, G B	1665	1,450	Visible Stars	Long, Lat	1701 0	"Catalogus Fixarum Universalis ad annum Christi 1700 completum" Consists of stars numbered in 4 classes — 1st Class consists of 110 stars often observed by Riccioli and Grimaldi, and includes the *Pleiades* observed by Vincentio Mutus and Langrenus 2nd Class 958 small stars from the Rudolphine Tables 3rd Class 246 small stars observed by Hipparchus and Ptolemy, and not by Riccioli or Tycho 4th Class 136 stars in the New (Southern) Constellations observed by navigators In "Astronomiæ Reformatæ'
72	Hire, Phillipe de la	1727	64	Prin Stars	R A, Decl	1701 0	"Tabulæ Astronomicæ Ludovici Magni 2nd ed by De la Hire, Parisiis, 1727," p 13
73	Hire Phillipe de la	1727	17	Prin Stars	Long, Lat	1701 0	'Tabulæ Astronomicæ Ludovici Magni 2nd ed by De la Hire, Parisiis, 1727," p 13
74	Halley, Edmund, Ast Roy	1752	140	Prin Stars	Long, Lat	1720 0	'Astronomical Tables, with Precepts for computing the places of the Sun &c, London, 1752'
75	Halley (Sharp, Abr)	1725	265	Visible Stars	Long Lat R A, South Decl	1726 0	Halley's Southern Stars brought up to the later epoch by Abraham Sharp Flamsteed "Historia Cœlestis,' vol iii
76	Leadbetter, C	1728	777	Visible Stars	Long, Lat	1727 0	A Catalogue of 777 Fixed Stars, rectified to the beginning of the year 1727 In "Compleat System of Astronomy, London, 1728," vol ii p 209
77	Manfredi E	1731	14	1st Mag	Long, Lat, R A, Decl	1729 0	In "Commentarii Bononiensi, 1731,' vol i p 604

103	Bradley, J , Ast Roy	1771	387	Prin Stars	Long , Lat , R A , N P D	1760 0	"A Catalogue of the Places of 387 Fixed Stars in R A , Decl , Long , and Lat ," "Nautical Almanac, 1773," App p 25 Reduced by Chas Mason from Bradley's observations The R A s of 15 of these stars were settled by comparison with the Sun about the Equinoxes from the mean of 1175 observations These were the radical points by which the R A s of the other stars were reduced
104	Bradley, J , Ast Roy	1798	389	Prin Stars	R A , N P D	1760 0	In "Bradley's Astronomical Observations (Hornsby)," vol i
105	Cassini de Thury	1767	14	1st Mag	R A , Decl	1764 0	Made with a 6-ft mural circle In "Acad des Sciences Mems , 1764,' p 406
106	A Complete Catalogue of the Fixed Stars		376	To 7 Mag	R A , N P D	1764 0	"A Complete Catalogue of the Fixed Stars, with their respective places in the Heavens, as settled from the latest and most accurate Observations made both at Home and Abroad" In ' Miscellanea Scientifica Curiosa, London," no date, No iv p 98, Stars in the Constellation *Aries* (66), No v p 126, ditto *Taurus* (141) No vi p 164, ditto *Gemini* (87), No vii p 188 ditto *Cancer* (82)
107	Bernoulli	1776	110		Differences of R A	1765 0	"Table de Différences d Ascension Droite pour 110 Étoiles tirée des Catalogues de M Lacaille, Bradley, Mayer et Le Monnier, Recueil pour les Astronomes," tome iii p 122
108	Lacaille (Bailly)	1763	515	Zodiacal Stars	R A , Decl	1765 0	Lacaille's Observations, reduced by M Bailly In "Ephémérides des Mouvements Célestes, 1763"
109	Maskelyne, N Ast Roy (Hertzsprung)	1865	231	6 to 11 Mag	R A N P D (Approx.)	1770 0	"Reduction af Maskelyne's Iagttagelser af Smaa Stjerner, anstillede I Aarene fra 1765 til 1787, Kjøbenhavn, 1865" In "Copenhagen Dansk Vid Selsk Skrif," vol vi
110	Maskelyne, N Ast Roy	1774	34	Prin Stars	R A., N P D	1770 0	"Tables for computing the Apparent Places of the Fixt Stars, London, 1774,' p 5 The R A s from observations in 1765 to 1769 of differences of R A with *α Aquilæ*, N P D s from observations in 1765
111	Bernoulli	1772 1776	51	Circumpolar Stars	R A., Decl	1772 0	"Tables d'Étoiles Circonpolaires" In "Recueil pour les Astronomes,' tomes ii p 75, and iii p 1
112	Maskelyne, N Ast Roy (Main, R)		36	Prin Stars	Right Ascen	1765 0 to 1772 0 1779 0 to 1785 0 1796 0 to 1801 0 1803 0 to 1807 0	"Catalogues of the Concluded Mean Right Ascensions of Stars compared with *α Aquilæ*, arranged by the Rev R Main ' In "Greenwich Observations, 1851," Appendix ii "Maskelyne's Ledgers of Stars"
113	Mayer Christian	1779	72	Double Stars	R.A , Decl.	1777·0	De Novis in Cœlo Sidereo Phœnomenis, Mannheim, 1779 p 127 Tabula Nova Stellarum Duplicium ex Observationibus in Specula Electorali Mannheimensi factis, Quadrante Murali Birdii VIII Pedum The First Catalogue of Double Stars Does not give Distances or Position Angles

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places Co ordinates	Epoch	Notes.
						A D	
114	Mayer, Christian	1781	80	Double Stars	R A Decl	1777 0	In 'Berlin Ast Jahrb, 1784,' from C Mayer s observations at Mannheim
115	Darquier, M	1782	270	To 7 Mag	R A 12ʰ to 19ʰ, Dec +20° to +34°	1780 0	'Observations Astronomiques faites a Toulouse, Paris, 1782' A Supplement to the British Catalogue for the Constellations *Coma Bootes, Corona Hercules,* and *Lyra* contains only 49 stars of Flamsteed
116	Bode, J E	1782	5 058	To 7 Mag	R A , Decl	1780 0	"Representation des Astres sur 34 Planches" Berlin and Stralsund 1782
117	Bode, J E	1782	280	Prin Stars	R A , Decl	1780 0	
118	Lalande, J	1778	258	Prin Stars	Long , Lat	1781 0	Table of the Aberration and Nutation in R A and Decl of 258 Principal Stars In "Conn des Temps 1781,' p 223
119	Lacaille, Abbé de	1782			R A Decl	1784 0	Catalogue of Lacaille's Stars not in Flamsteed's British Catalogue In "Conn des Temps, 1785"
120	Flamsteed (Jeaurat)	1782	2 934	To 7 Mag	R A , Decl	1784 0	Flamsteed s British Catalogue reduced by Jeaurat to 1784 0 In 'Conn des Temps, 1785" p 182
121	Jeaurat		64	*Pleiades*	R A , Decl	1786 0	Catalogue of Stars in the *Pleiades* "Acad des Sciences Mems 1779' p 519
122	Pigott E lw	1786	50	Variable Stars	R A Decl	1786 0	Phil Trans, 1786, p 189
123	Montignot	1786	1 022	Visible Stars	Long Lat	1786 0	Ptolemy s Catalogue reduced to Epoch 1786 État des Étoiles Fixes au second Siecle par Claude Ptolemee, compare à la position des mêmes etoiles en 1786, Nancy 1786
124	Montignot	1786	18	Prin Stars	Declinations	1786 0	Ptolemy s stars reduced and compared with places observed in 1786 In ditto
125	Cassini		138	Prin Stars	Declinations	1788 0	From observations with the 6-foot quadrant of the Paris Observatory stars arranged according to Bayer s letters Acad des Sciences Mems 1789 p 139 (includes previous Catalogues in Mems de l Acad 1784 to 1788)
126	Lacaille (Delambre)		400	Visible Stars	R A Decl	1788 0	Lacaille's Stars with the Annual Variations in R A and Decl brought up to later epoch Conn des Temps 1788
127	Pond, J , Ast Roy		35	Prin Stars	Right Ascen	1788 0	R A s computed for the year 1788 by interpolation, compared with positions obtained for the same year by actual observation Greenwich Observations," 1820-1822
128	Maskelyne N Ast Roy	1789	36	Prin Stars	Right Ascen	1790 0	In Wollaston s Specimen of a General Catalogue London, 1789

129	Maskelyne, N , Ast Roy	1798	36	Prin Stars	R A , N P D	1790 0	
130	Wollaston, Francis	1789	7,620	Stars, Nebulæ, and Clusters	R A , N P D +90° to −90°	1790 0	‘A General Catalogue of Stars, Nebulæ, and Clusters of Stars whose positions have been ascertained, arranged in the order of R A in their respective Zones of N P D” Consists of stars from the British Catalogue, Lacaille's three Catalogues, T Mayer s Zodiacal Stars and Bradley s 380 stars from Naut Alm 1773, Nebulæ and Clusters from Messier (“Conn des Temps 1784”) and Herschel In “Specimen of a General Catalogue, London, 1789”
131	Wollaston, Francis	1789	4,881	To 7 Mag	R A N P D	1790 0	“Flamsteed's British Catalogue, and Lacaille's Southern Catalogue arranged in order of R A ,” includes 80 circumpolar stars from Hevelius, omitted by Flamsteed Specimen of a General Catalogue ’
132	Wollaston, Francis	1789	2,069	Zodiacal Stars	Long , Lat	1790 0	“Catalogue of Zodiacal Stars within 9° of Latitude on each side of the Ecliptic, arranged in the order of Longitude,” from Flamsteed, Lacaille, Bradley, and Mayer ‘ Specimen of a General Catalogue”
133	Lalande		34	Prin Stars	Declinations	1790 0	In “Conn des Temps, 1793 ’
134	Lalande		350	Prin Stars	Declinations	1790 0	Made with the mural circle at the École Militaire, Paris “Conn des Temps, 1794”
135	Lalande, Jerome de		1,063	Visible Stars	Declinations	1790 0	Made with the 7½ feet mural circle at the École Militaire “Conn des Temps, 1795 ’
136	Lalande ..		17	Prin Stars	Right Ascen	1790 0	The R A s were determined with the greatest precision “Conn des Temps, 1794 ’
137	Lalande		139	Northern Stars	Right Ascen	1790 0	“Conn des Temps, 1795”
138	Lalande		1,000	Circumpolar Stars	Right Ascen	1790 0	“Conn des Temps 1797”
139	Lalande, M L ...		150	Prin Stars	Right Ascen	1790 0	Fundamental stars for Lalande s Zone Catalogue of 45,000 Stars “Conn des Temps, 1798 ’
140	Cassini		33	Prin Stars	Declinations	1790 0	“Conn des Temps, 1795”
141	C Lefrançais		34	Prin Stars	Right Ascen	1790 0	Determined with the greatest precision” “Conn des Temps, 1797 ’
142	Lalande			Stars to 10 Mag		1790 0	Zone Catalogue contained in “Conn des Temps, 1799 to 1805 ’
143	Lalande, M F		240	Prin Stars	Right Ascen	1790 0	‘Conn des Temps, 1800”
144	Lalande (Federenko J)	1854	4,673	To 9 Mag	R A , Decl	1790 0	“Positions Moyennes pour l'Époque de 1790 0 des Étoiles Circompolaires dont les observations ont été publiées par Jerome Lalande dans les Mémoires de l'Acad de Paris de 1789 et 1790 ’”
145	Lalande (Federenko J)	1854	339	To 9 Mag	R.A , Decl	1790 0	A supplementary Catalogue of 339 Stars is appended St-Petersbourg, 1854 (For corrections to this Catalogue see “Argelander, Bonner Beobachtungen,’ vol vi p 22)

No	Name.	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
						A D	
146	Lalande (Oeltzen W) ..		193		R A Hours VI to XXIII Decl +70° to Pole	1790 0	"Erganzungen zur Histoire Celeste Française und einigen andern Sternkatalogen, Vienna Acad Sitzber," vol xii p 911
147	Le Monnier	.	31	Præsepe	R A , Decl	1790 0	Catalogue of Stars in Præsepe In "Acad des Sciences Mems , 1789" p 610
148	Vidal (Flaugergues)	1804	24	Circumpolar to 9 Mag	R A Decl	1790 0	"Catalogue d'Étoiles Circompolaires observees par M Vidal et reduite par M Flaugergues" "Conn des Temps, an 15 1807' p 238
149	Mayer, T (Vince)	1797	992	Zodiacal Stars	R A Decl	1790 0	Reduced by S Vince from the Gottingen observations, 1756 to 1761 "Vince's Astronomy," vol ii
150	Zach, Baron de	1795	39		Declinations	1792 0	Reduced from Piazzi's observations In "Berlin Jahrbuch, Supp II, 1795" p 111
151	Perny, C		14	Prin Stars	Declinations	1795 0	"Conn des Temps, 1796"
152	Messier, C	1807	23	Small Stars	R A , Decl	1795 0	Stars near the nebula 31 Messier, Andromedæ In 'Acad des Sciences Mems , 1807
153	Piazzi, G		34	Prin Stars.	Declinations	1795 0	'Palermo Observations," vol v p 207
154	Lalande, C ..	1796	9		Long , Lat	1798 0	Stars from Maskelyne and Lalande
155	Vidal, Jacques		887		R A Decl −30° to −45°	1799 0	Catalogue of Southern Stars observed at Mirepoix, reduced to 12 Nivose An 7 In "Conn. des Temps, 1802"
156	Mougin, C		1,588				Catalogue of Precessions 'Conn des Temps, 1802'
157	Mougin, C		600	Prin Stars		1799 7 & 1899 7	Catalogue of the Annual Variations of 600 Stars "Conn des Temps, 1803"
158	Zach Baron de		354	Zodiacal Stars	Right Ascen	1800 0	"Conn des Temps, 1800
159	Zach, Baron de	1792	381	Prin Stars	Right Ascen	1800 0	"Tabulæ Motuum Solis Novæ, Fixarum Præcipuarum Catalogus Novus, Gothæ, 1792 Catalogue of Stars made from observations at Gotha, 1787 to 1790
160	Zach Baron de	1792	162	Prin Stars	Declinations	1800 0	'Tabulæ Motuum Solis Novæ, Gothæ'
161	Zach, Baron de	1806	1,827	Zodiacal Stars	Right Ascen	1800 0	"Stellarum Zodiacalium Catalogus Novus ex Observationibus in Specula Astronomica Ernestina in Monte Seeberg factis exhibens" Stars arranged in order of Signs In Tabulæ Speciales Aberrationis, Gothæ, 1806,' vol 1
162	Zach, Baron de	1822	33	Red Stars	R A , Decl	1800 0	'Zach, Corresp , vol vii p 298
163	Zach, Baron de	1806	1 826	Zodiacal Stars	Declinations	1800 0	' Stell Zod Cat Nov ex Observationibus in Specula Electorali Mannhemensi factis exhibens" Stars arranged in order of Signs In "Tabulæ Speciales Aberrationis," vol 1

164	Zach, Baron de	1822	28	Variable Stars	R A , Decl	1800 0	Observations on Changeable Stars and Stars of Different Colours" "Edinburgh Phil Jour," vol ix "Zach Corresp," vol vii
165	Lalande, Jerome de (British Association)	1847	47,390	To 10 Mag	R A , Decl	1800 0	"A Catalogue of those Stars in the 'Histoire Céleste Française' of Jérôme De Lalande for which Tables of Reduction to the Epoch 1800 have been published by Prof Schumacher," reduced by Baily at the expense of the British Association, London, 1847
166	Lalande (Argelander)	1869	3,082		R A , N P D	1800 0	'Corrigirte Positionen in Lalande's Catalog nach der Ausgabe der British Association In "Bonn Ast Beob," vol vii p 213
167	Cagnoli, A	1803	473	Prin Stars	R A , North Decl	1800 0	'Catalogo di Stelle Boreali, Modena, 1803' Northern stars In "Modena Soc Ital Mem," vol x p 687
168	Cagnoli, A	1803	28	Prin Stars	R A South Decl	1800 0	Southern stars In "Modena Soc Ital Mem.,' vol x p 687 (Supplement containing corrections to the above "Modena Soc Ital Mem, 1804," vol xi p 676)
169	Agelet, Le Paute D (Gould)	1866	2 907	To 9 Mag	R A , Decl +50° to −35° 30′	1800 0	"Reduction of the Observations of Fixed Stars made by Joseph Le Paute D'Agelet, at Paris in 1783–1785 by B A Gould, Washington, 1866" In 'Washington National Acad Mems" vol i
170	Groombridge, S		38	Prin Stars	N P D	1800 0	"Comparison of the N P D s of 38 Principal Fixed Stars on the 1st of January 1800, as determined by observations made at Greenwich, Armagh, Palermo, Westbury, Dublin, and Blackheath In Edinburgh Soc Roy Trans, vol vii
171	Lalande, J de (Labaume, B)	1822	1,504	To 9 Mag	R A hour 0, Decl	1800 0	'Catalogue des Étoiles de l'Hist Cel Fran de M J Le Français, De Lalande calculé pour l'an 1800 par Berenger Labaume Does not include any of Piazzi's stars In "Zach Corresp,' vol vii
172	Wollaston, Francis	1800	259	Circumpolar Stars	R A , N P D 0° to 24° in zones	1800 0	"Fasciculus Astronomicus, containing observations of the Northern Circumpolar Region &c, London, 1800"
173	Piazzi, G	1803	6,748	To 8 Mag.	R A., Decl	1800 0	'Præcipuarum Stellarum inerrantium Positiones Mediæ Ineunte Sæculo XIX ex observationibus habitis in Specula Panormitana ab anno 1792 ad annum 1802 Panormi, 1803" Consists of a Catalogue of 6,354 Stars, arranged in separate catalogues for each hour of R A, and a Supplementary Catalogue of 740 Stars, of which 394 are not found in the previous catalogue
174	Piazzi, G	1814	7,646	To 9 Mag	R A , Decl	1800 0	'Præcip Stell inerr Pos Med ineunte sæculo XIX ex observationibus habitis in Specula Panormitana ab anno 1792 ad annum 1813, Panormi, 1814." Stars numbered for each hour R A (For the original observations see 'Annalen der K K Sternwarte der Wien' vols iv to xii 2nd series

No	Name,	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
						A D	
175	Piazzi, G		28	*Pleiades*	R A , Decl	1800 0	In "Berlin Jahrbuch, 1817," p 223
176	Bode, J E	1805	5,505	To 7 Mag	R A , Decl	1800 0	"Catalogue de l'Ascension Droite et de la Declinaison de 5,505 Étoiles, d'après les observations de M le Dr Piazzi a Palerme, Berlin, 1805" Contains also a Catalogue of 372 Nebulæ and Clusters, from the observations of Herschel, Messier, Mechain, and others
177	Henry, Abbe	1801	12	Prin Stars Circumpolar	Declinations	1800 0	"Observations de quelques Étoiles," made with the mural quadrant at the Observatory, St Petersburg, in 1797 and 1798 The declinations presuppose the instrumental error to be nil, and the latitude of the observatory to be known exactly In "Nova Acta Petropolitanæ," vol xii p 456
178	Harding, K L	1822 1st ed, 1856 2nd ed	60,000	To 9 Mag	R A , Decl +90° to −30°	1800 0	' Neuer Himmelsatlas von 27 Tafeln, enhaltend die bis jetzt zwischen dem Nordpol und dem 30 Grade sudlicher Abweichung beobachteten Sterne, Halle a S 1856"
179	Harding		91	Stars 6 to 8 Mag	R A , Decl	1800 0	"Stern Verzeichniss" In "Zach Monat Corresp," vol xxviii p 310
180	Berlin Academy Star Catalogue and Charts	1859	40,059	To 9 Mag	R A , Decl +15° to −15°	1800 0	'Cataloge zu den 24 Stunden der Akademischen Sternkarten, Berlin, 1859" Contains catalogues for each hour R A by different observers, arranged in order of R A

Hora	0	1,356 Stars	Luther
„	1	1,299 „	Olufsen
,	2	1,447 „	Morstadt
	3	1,427 ,	D'Arrest
	4	1 720 „	Knorre
	5	2,095 ,	Argelander and Schmidt
,	6	2 559 ,	Bremiker
,	7	2 373 ,	Fellocker
,	8	2,045	Wolfers
	9	1 599 ,	Bremiker
	10	1 680	Gobel
,	11	1,304	Boguslawski

							Hora 12 1,286 Stars Steinheil
							13 1,370 " Bremiker
							" 14 1,445 " Hussey
							15 1,557 " Harding
							, 16 1,422 " Wolfers
							17 1,642 " Bremiker
							, 18 2,036 " Inghirami and Capocci
							" 19 1,970 " Wolfers
							, 20 1,847 , Hencke
							21 1,644 " Bremiker
							" 22 1,436 " Argelander
							" 23 1,500 " Harding
181	Ptolemy (Bode)	1795	1 022	Visible Stars	Long , Lat	138 & 1800 0	Ptolemy's Catalogue reduced to 1800 and compared with recent observations In "Beobachtung und Beschreibung der himmlischen Sphare, Berlin und Stettin, 1795," p 90
182	Ptolemy (Bode)	1795	35	Prin Stars	Longitudes	63 & 1800	Ptolemy's longitudes reduced to 1800 and compared with Mayer s Catalogue, assuming the places in the "Almagest" to be for Epoch A D 63 In "Beobachtung und Beschreibung der himmlischen Sphare, Berlin und Stettin, 1795," p 235
183	Catalogue of 1,800 Zodiacal Stars ' (uncompleted)	1821–23	789	To 8 Mag	R.A 0° to 134° Decl	1800 0	"A Catalogue of 1800 Zodiacal Stars for the Epoch of Jan 1 1800, from the works of Piazzi Bode, and others, by a Member of the Astronomical Society of London" In 'Tilloch's Phil Mag and Jour,' vol lviii pp 114, 367, vol lxii p 47
184	Inghirami, G .	1829	2,039	To 9 Mag	R A Hora XVIII , Decl + 15° to – 15° in zones	1800 0	"Mappa Uranographica, Firenze, 1829" Berlin Acad Catalogue for Hora XVIII, arranged in zones, made at the Florence Observatory
185	Labaume, B	1831	195	Double Stars.	R A , Decl	1800 0	'A Catalogue of 195 Double Stars taken from the 'Histoire Celeste of M F Lalande ' In "Ast Soc Roy Mems " vol iv Gives places only, no measurements
186	Pond, J Ast Roy	1806	29	Prin Stars	N P D	1800 0	From observations at Greenwich between 1800 and 1802, compared with observations at Palermo and Westbury during the same period, and observations at Armagh in 1797 "Phil Trans, 1806" p 453

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates.	Epoch	Notes
						A D	
187	Oltmanns	1808	84	Zodiacal to 5 Mag	Long , Lat	1800·0	"Verzeichniss der Langen und Breiten einiger Sterne fur den Anfang des Jahres 1800" Zodiacal stars liable to occultation In "Berlin Jahrb Supp 1808," p 224
188	Oltmanns	1808	878	To 8 Mag	R A , Decl	1800·0	"Erstes Supplement zu Herrn D Piazzi's Stern Verzeichniss, zusammengetragen von Herrn Jabbo Oltmanns In "Berlin Jahrb Supp , 1808," p 167
189	Bode, J E	1801	17,240	Stars to 8 Mag and Nebulæ	R A , Decl	1801·0	"Description et Connoissance genérale des Constellations, Berlin, 1801" (French and German) Contains catalogues of 14,470 fixed stars, 421 double stars, 1,802 nebulæ, 212 clusters, and 335 double stars of doubtful position Separate catalogues of the stars and nebulæ in each constellation
190	Maskelyne N , Ast Roy	1805	36	Prin Stars	R A , N P D	1802·0	"The Mean R A s and N P D s of 36 Principal Fixed Stars for the beginning of the year 1802' In "Greenwich Observations, 1802 and Zach, "Tabulæ Aberrationis. Catalogue of fundamental stars, with a table of corrections of the R A s in time to every 10th day of the year To serve from 1800 to 1850, or even through the century
191	Oltmanns J	1810	36	Prin Stars	R A , N P D	1802·0	"Recueil d'Observations Astronomiques, par A de Humboldt, Paris, 1810,' vol 1 p 9 Catalogue reduced by Oltmanns from Greenwich observations made in 1801 and 1802
192	Chabrol, G M		600	Prin Stars	Long , Lat	1802·0	In "Conn des Temp , 1803"
193	Cacciatore (Auwers)	1865	46	Fund Stars	Right Ascen	1805·0	Rectascensionen der Fundamentalsterne fur 1805" New determination of the R A s of fundamental stars, from observations at Palermo, 1803 to 1805 In "Ast Gesell Pub" No V and "Ast Nach ," No 1,504
194	Palermo Catalogue	1806	120	Prin Stars	R A Decl	1805·0	"Del Reale Osservatorio di Palermo ' Lib Sesto Palermo, 1806
195	Palermo Catalogue	1806	100	Prin Stars	R A , Decl	1805·0	"Del Reale Osservatorio di Palermo ' Lib Sesto Palermo, 1806
196	Palermo Catalogue	1806	210	Prin Stars	R A Decl	1805·0	"Del Reale Osservatorio di Palermo" Lib Sesto Palermo, 1806
197	Bode, J E	1808	210	To 8 Mag	R A , Decl	1805·0	"Zweites Supplement aus der Herrn D Piazzi's Del Reale Osservatorio di Palermo Lib VI von mir entlehnt (S Astron Jahrb 1810 Seite 268)" In "Berlin Jahrb Supp 1808,' p. 190
198	Nautical Almanac		9	Prin Stars	Long , Lat	1809·0	' Catalogue of the Longitudes of 9 Principal Fixed Stars to the beginning of 1809, and their Latitudes to the Middle of the Year ' ' Nautical Almanac, 1813," p 162

199	Lalande, J		33	Red Stars	R A		"Conn des Temps an 15, 1807,' p 378
200	Groombridge, S (Airy)	1838	4,243	To 9 Mag Circumpolar	R A., Decl	1810 0	' Catalogue of 4,243 Circumpolar Stars, deduced from the Observations of Stephen Groombridge, Edited by G B Airy, Ast Roy, London, 1838"
201	Vecchi, Domenico de	1810	43	Prin Stars	R A , Decl	1810 0	"Catalogo di 43 Stelle prossime al Zenit dell' Osservatorio, Florence, 1810" In "Annali del Museo Imperiale," vol ii
202	Oriani, B	1814	30	Prin Stars Circumpolar	Declinations	1811 0	Made from observations with a 3 foot circle at the Milan Observatory In "Effem Ast, Milano, 1815," Appendix
203	Oriani, B	1816	40	Prin Stars	Declinations	1811 0	From mural circle observations at Milan In "Effem Ast, Milano 1817," Appendix
204	Brinkley, J	1815	47	Prin Stars	N P D	1813 0	"A Catalogue of N P D s of 47 Principal Fixed Stars, from recent Observations" In "Irish Acad Roy Trans," vol xii
205	Pond, J, Ast Roy	1813	44	Prin Stars	N P D	1813 0	From observations at Greenwich with the mural circle in 1812 "Phil Trans 1813" p 76
206	Pond, J, Ast Roy	1813	84	Prin Stars	N P D	1813 0	From observations at Greenwich in 1813 In "Phil Trans, 1813," p 282
207	Pond, J, Ast Roy	1815	30	Prin Stars	N P D	1813 0	Standard Greenwich Catalogue, from observations with the mural circle in 1814 In "Phil Trans, 1815," p 386
208	Wollaston, Francis	1811		Stars to 6 Mag and Nebulæ	.		"A Portraiture of the Heavens as they appear to the Naked Eye, London 1811' Ten maps without catalogue
209	Struve, F G W	1817	192	Prin Stars	Right Ascen	1814 0	Stars between 45° and 75° Decl In "Dorpat Observations, 1814 to 1815," vol i p 45
210	Struve, F G W	1817	90	Prin Stars	Right Ascen	1815 0	In "Dorpat Observations," vol i p 65
211	Pond, J, Ast Roy		36	Prin Stars	Right Ascen	1815 0	Catalogue reduced by Pond from the latest observations of Maskelyne In ' Greenwich Observations, 1811–1813"
212	Pond, J, Ast Roy		44	Prin Stars	N P D	1815 0	From observations at Greenwich with the mural circle in 1812 and 1813 In "Greenwich Observations, 1811–1813"
213	Pond, J, Ast Roy		400	Prin Stars	N P D	1815 0	From observations at Greenwich, 1814 to 1816 In "Greenwich Observations, 1814–1816"
214	Bessel, F W	1818	36	Prin Stars	Right Ascen	1815 0	From observations at Konigsberg, 1814 to 1818 In "Berlin Acad Abhand, 1818–1819," and "Edinburgh Phil Jour,' vol i
215	Littrow	1817	23	Fund Stars	N P D	1815 0	"Mittlere Poldistanzen für den Anfang des Jahres, 1815" Lindenau Zeitschrift, vol iv p 85 N P D s by Bessel, Piazzi, Pond, and Oriani
216	"Companion to the Transit"	1815		1st to 4th Mag	R.A , Decl	1815 0	London, 1815

No.	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co-ordinates	Epoch	Notes
217	Pond, J., Ast. Roy.	1818	400	Prin. Stars	R.A., N.P.D. 40° to 120°	A.D. 1817·0	"Greenwich Observations, 1814–1816
218	Pond, J., Ast. Roy.		37	Prin. Stars	N.P.D.	1813·0 to 1818·0	Catalogue corrected by a comparison of observations made in 1822 with those of 1812 and 1813. In "Greenwich Observations, 1820–1822."
219	Pond, J., Ast. Roy.			Prin. Stars	N.P.D.	1818·0	Observed N.P.D.s reduced to the beginning of 1818, interpolated from observations 1812 to 1823. In "Greenwich Observations, 1820–1822."
220	Pond, J., Ast. Roy.		37	Prin. Stars	N.P.D.	1818·0 to 1823·0	In "Greenwich Observations, 1820–1822."
221	Pond, J., Ast. Roy.		36	Prin. Stars	Right Ascen.	1819·0	From five years' observations with the new transit, 1817 to 1821, compared with Maskelyne's Catalogue of 1805, reduced to same period. In "Greenwich Observations, 1820–1822."
222	Pond, J., Ast. Roy.		36	Prin. Stars	R.A.	1820·0	In "Greenwich Observations, 1817–1819."
223	Pond, J., Ast. Roy.		36	Prin. Stars	R.A.	1766–1784 1802–1820	In "Greenwich Observations, 1820–1822."
224	Bessel, F. W.		59	Prin. Stars	N.P.D.	1820·0	In "Königsberg Observations," vol. vii. p. xxiv.
225	Bessel, F. W.		36	Prin. Stars	Decl.	1820·0	In "Edinburgh Phil. Jour.," vol. vii.
226	Bessel (Dollen, W.)	1853	59	Prin. Stars	N.P.D.	1820·0	"Neue Reduction der Königsberger Declinationen, 1820," St.-Pétersbourg, 1853. "Acad. Imp. Mém. Mat. et Phy., 1853," vol. vii.
227	Bessel (Dollen, W.)	1853	45	Prin. Stars	Decl.	1820·0	
228	Bessel (Wurm)	1825	13	*Pleiades*	Long., Lat.	1820·0	From Bessel's Observations. In "Ast. Nach.," No. 61.
229	Inghirami, G.	1826	3,396	Zodiacal Stars to 8 Mag.	R.A., Decl.	1820·0	"Metodo e Tavole per construire un Efemeride di Occultazioni delle Fisse sotto la Luna, Firenze, 1826."
230	Brioschi, C.	1824–1826	32	Fund. Stars	Decl.	1820·0	"Comentari Astronomici della Specola Reale di Napoli, Napoli, 1824–1826," vol. i. Catalogue made from 2,198 observations.
231	Caturegli	1819	519	Zodiacal Stars to 6 Mag.	Long. Lat. +7° to −7°	1800·0 & 1820·0	Places from the New Palermo Catalogue. In "Ephemerides Motuum Cœlestium, 1817 to 1822, Bologna, 1819."
232	Caturegli	1822	36	*Pleiades*	Long., Lat., R.A., Decl.	1820·0 & 1800·0	Places from the observations of Caturegli and Piazzi. In "Ephemerides Motuum Cœlestium, 1823 to 1828, Bologna, 1822." Appendix.
233	Struve, F. G. W.	1822	67	Prin. Stars	R.A., Decl.	1820·0	Approximate places from Piazzi. In "Dorpat Observations," vol. iii. p. viii.

234	Struve, F G W	1822	800	Double Stars	R A , Decl	1820 0	"Catalogus Stellarum Duplicium a 20° Decl Austr ad 90° Decl Bor" Catalogue of approximate positions No measurements In "Dorpat Observations," vol iii p xv
235	South, J	1822	477	Double Stars	R A , Decl	1821 0	"Observations on the Best Mode of Examining the Double and Compound Stars, together with a Catalogue of those whose Places have been identified" Arranged from Bode's Cat , published 1801 Gives measurements of distance In 'Ast Soc Roy Mems ," vol i
236	Pond, J , Ast Roy		38	Prin Stars	N P D	1822 0	Four Catalogues of N P D s deduced by the following methods — 1 Computed in the usual manner by direct measurement from the Pole 2 By the angular distance of the stars from their reflected images in an artificial horizon 3 Computed in the same manner as 2, but from observations with two microscopes only 4 Computed from observations with two microscopes in the same manner as No 1 In "Greenwich Observations, 1820–1822"
237	Pond, J Ast Roy		37	Prin Stars	N P D	1822 0	From observations at Greenwich, Nov 1, 1821, to June 1, 1822 In "Greenwich Observations, 1820–1822"
238	Baily, Francis	1822	64	*Pleiades*	R A , Decl	1822 0	In "Astronomical Tables and Remarks for the year 1822, London, 1822'
239	Baily, Francis	1822	504	Stars to 4 5 Mag	R A , Decl	1822 0	Stars observed by Bradley and Piazzi In "Astronomical Tables and Remarks for the year 1822, London, 1822"
240	Baily, Francis	1822			R A , Decl	1822 0	All stars in preceding Catalogue within 30° of Equator In "Astronomical Tables and Remarks for the year 1822, London, 1822"
241	Pond, J , Ast Roy		72	Prin Stars	R A , N P D	1823 0	Subsidiary Catalogue In "Greenwich Observations, 1823"
242	Pond, J , Ast Roy		134	Prin Stars	R A , N P D	1823 0	Result of observations from the beginning of September 1821 to the end of 1823 In "Greenwich Observations, 1823"
243	Pond, J , Ast Roy		60	Prin Stars	R A , N P D	1823 0	In "Greenwich Observations, 1823'
244	Pond, J , Ast Roy	1823	45	Prin Stars	R A , N P D	1823 0	General Catalogue In "Phil Trans , 1823," p 68, and "Greenwich Observations, 1820–1822"
245	Pond, J , Ast Roy	1823	37	Prin Stars	N P D	1823 0	In "Phil Trans , 1823," p 61
246	Brinkley, J	1824	43	Prin Stars	N P D	1813 0 & 1823 0	In "Phil Trans , 1824," p 80
247	Rumker, C	1827	20	Prin Stars	S P D	1823 0	From observations at Paramatta In "Ast Nach ," No 102
248	Rumker, C	1826	63	Prin Stars.	S P D	1823 0	Includes 10 Fundamental Stars In "Ast Nach ," No 82

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
						A D	
249	Brinkley, J	1826	46	Prin Stars	R A	1824 0	"A Catalogue in R A of 46 Principal Stars, deduced from Observations made at the Observatory, Trinity College, Dublin, in 1823 and 1824" In "Ast Nach," No 78 "Edinburgh Phil Jour," vol xiv
250	Fallows, Fearon	1824	273	Prin Stars	R A, S Decl	1824 0	"A Catalogue of nearly all the Principal Fixed Stars between the Zenith of Cape Town, C G H, and the South Pole" In "Phil Trans, 1824," p 465 "All the Declinations must be diminished 4 seconds" (note by F Fallows to Catalogue)
251	Struve, F G W,	1830	35	Fund Stars	Decl	1824 0	Compared with Bessel In "Dorpat Observations," vol vi p lvii
252	Struve, F G W	1852	42	Double Stars	Declinations	1824 0	"Declinationes Mediæ Stellarum Circumpolarium pro 1824 0' In "Stell Fix Dup et Mult. Pos Med," p xxxiv
253	Struve, F G W	1852	32	Fund Stars	Declinations	1824 0	"Declinationes Stellarum 32 Fundamentalium" In "Stell Fix Dup et Mult Pos Med," p xxxix
254	Struve, F G W	1852	68	Prin Stars	Right Ascen	1824 0	"Ascensiones Mediæ Stellarum Circumpolarium" In "Stell Fix Dup et Mult Pos Med," p xxxxiii
255	Struve, F G W	1852	109	Prin Stars	R A, Decl	1824 0	"Stellarum Primariarum 109 et Fundamentalium et borealium Positiones Mediæ pro Epocha, 1824 0" In "Stell Fix Dup et Mult Pos Med," p xxxxviii
256	Struve, F G W	1852	35	Fund Stars	Right Ascen	1825 0	"Catalogus Ascensionum Rectarum Stellarum Fundamentalium ad justas et aberrationes et nutationes emendatarum" In "Stell Fix Dup et Mult Pos Med," p xxxxi
257	Bessel (Weisse)	1846	31,085	To 9 Mag	R A, Dec −15° to +15°	1825 0	"Positiones Mediæ Stellarum Fixarum in Zonis Regiomontanis a Besselio, Petropoli, 1846" Stars arranged and numbered in hours of R A Reduced from the Konigsberg Zone Observations, 1821 to 1831
258	Bessel (Weisse)	1863	31,445	To 9 Mag	R A, Dec +15° to +45°	1825 0	"Positiones Mediæ Stellarum Fixarum, Petropoli, 1863' Continuation of Bessel's Konigsberg Zone Observations, 1821 to 1831
259	Paramatta Catalogue (Brisbane)	1835	7,385	To 9 Mag	R A, Decl	1825 0	"A Catalogue of 7,385 Stars, chiefly in the Southern Hemisphere, prepared from Observations made in the Years 1822–1826, at Sir Thomas Brisbane's Observatory at Paramatta" Observations reduced by W Richardson, London, 1835
260	Bessel, F W	1826	36	Fund Stars	R A	1825 0	"Neuester Fundamental Catalog" Fundamental Stars In "Ast Nach" No 78

261	Brinkley, J	1828	48	Prin Stars	R A , N P D	1825 0	"On the quantity of the Precession of the Equinoxes as determined by certain Stars that appear to have no Proper Motion" In "Irish Acad Roy Trans," vol xv
262	Bessel, F W	1823	194	Small Stars	R A XX Hr to III Hr , Decl	1825 0	Reduced from the Konigsberg Zones In "Ast Nach," No 17
263	Bessel, F W	1841	27	*Pleiades*	R A , Decl	1825 0	In "Ast Nach," No 387, and "Ast Unters"
264	Bessel, F W		257	Double Stars	R A , Decl	1825 0	Verzeichniss von 257 auf der Konigsberg Steinwarte beobachteten Doppelsternen Gives measurements of distances In "Ast Nach," No 88
265	Plana, G	1828	46	Fund Stars	Declinations	1825 0	From Turin observations with the Reichenbach 3-foot circle in the years 1822 to 1825 In "Turin Acad R Mem" vol xxxii p 464
266	Pond, J , Ast Roy		40	Prin Stars	N P D	1825 0	'First Approximation to a Standard Catalogue of 40 Stars observed Feb 1, 1825, to Feb 28, 1826" In "Greenwich Observations, 1825"
267	Pond, J , Ast Roy	1827	36	Prin Stars	R A	1825 0	From observations at Greenwich, 1817 to 1826 In "Ast Nach,' No 119
268	Struve, F G W	1830	35	Fund Stars	R A	1825 0	Compared with Bessel In "Dorpat Observations," vol vi p lxviii
269	Herschel, J F W	1826	321	Double Stars	R A , N P D	1825 0	"Account of some Observations made with a 20-feet Reflecting Telescope" Gives measurements of distances In "Ast Soc Roy Mems," vol ii
270	Herschel, J F W , and South, J	1825	380	Double Stars	R A , Decl		'Observations of the Apparent Distances and Positions of 380 Double and Triple Stars, made in the years 1821–23' In Phil Trans, 1824," part 3
271	South, J	1826	458 43	Double Stars Double Stars	R A Decl		Observations of the Apparent Distances and Positions of 458 Double and Triple Stars made 1823–25, with a re-examination of 43 Stars' Made at Passy, near Paris In "Phil Trans, 1826"
272	Pond, J , Ast Roy		40	Prin Stars	N P D	1826 0	Catalogue constructed from observed altitudes only, April 1, 1825, to March 1, 1827 In "Greenwich Observations, 1827"
273	Pond, J , Ast Roy		45	Prin Stars	R A , N P D	1826 0	In 'Greenwich Observations, 1825'
274	Pond, J , Ast Roy		60	Prin Stars	R A N P D	1826 0	The R A s from the Greenwich Catalogue of 1820 In 'Greenwich Observations, 1826"
275	Pond, J , Ast Roy		64	Prin Stars	N P D	1826 0	Final Catalogue, from observations with mural circles in the years 1825 to 1827 In "Greenwich Observations, 1826"
276	Pond, J , Ast Roy		63	Prin Stars	R A N P D	1826 0	The N P D s from observations with the mural circles, March 1825 to March 1828 In "Greenwich Observations, 1828," part 4
277	Pond, J , Ast Roy		45	Prin Stars	N P D	1756 1760 1770 1780 1790 1800 1810 1813 1820 1826	Catalogue of interpolated N P D s of 45 Principal Stars between the observed places 1756 and 1826 In "Greenwich Observations, 1828'

No	Name	Date published	Number of Stars	Description of Stars.	Mean Places, Co ordinates	Epochs	Notes
278	Pond, J, Ast Roy	1827	40	Fund Stars	N P D	A D 1826 0	Standard Catalogue from mural circle observations, 1825 to 1826 Appended are 21 additional stars, the N P D s of which are not so exact "In Ast Nach,' No 119 "Greenwich Observations, 1826"
279	Pond, J, Ast Roy	.	62	Prin Stars	R A, N P D	1826 0	In "Ast Nach," No 119 "Greenwich Observations, 1826"
280	Struve, F G W (Dorpat Catalogue)	1827	3 063	Double Stars	R A, Decl	1826 0	Catalogus Novus Stellarum Duplicium et Multiplicium, Dorpati 1827" Gives no measurements
281	Struve, F G W	1837	3,134	Double Stars	R A, Decl	1826 0	"Stellarum Duplicium et Multiplicium Mensuræ Micrometricæ per Magnum Fraunhoferi Tubum Annis a 1824 ad 1837, in Specula Dorpatensi institutæ Petropoli 1837' A Catalogue of Double Stars arranged in 8 orders of distances each order further subdivided into "Lucidæ" and "Reliquæ" Order 1 Dist 0″ to 1″ | Order 5 Dist 8″ to 12″ " 2 " 1 to 2 | 6 12 to 16 " 3 " 2 to 4 | " 7 " 16 to 24 , 4 , 4 to 8 | " 8 " 24 to 32 Also Catalogues of Double Stars more than 32″ in distance, and between 32″ and 7′ Gives measurements of distance and position
282	Struve, F G W	1841	45	Double Stars	R A, Decl	.	"Additamentum in Mens Micr" "St Petersb Acad Mems Mat et Phy," vol IV, 1841
283	Herschel, J F W	1833	364	Double Stars	R.A, N P D	1826 0	"Micrometrical Measures of 364 Double Stars with a 7-feet Equatorial Achromatic Telescope, taken at Slough in the years 1828 to 1830" Gives position and distance In "Ast Soc Roy Mems," vol V
284	Herschel, J F W	1835	146	Double Stars	R A, N P D	1826 0	"A Second Series of Micrometrical Measures of Double Stars, chiefly performed with the 7-feet Equatorial at Slough in the years 1831–1833" Gives position and distance In "Ast Soc Roy Mems," vol VIII
285	Rumker, C ..	1832	632	To 7 Mag	R A South Decl	1827 0	"Preliminary Catalogue of Fixed Stars intended for a Prospectus of a Catalogue of the Stars in the Southern Hemisphere included within the Tropic of Capricorn, Hamburgh, 1832"
286	Dunlop J	1829	253	Double Stars	R A, South Decl	1827 0	"Approximate Places of Double Stars in the Southern Hemisphere, observed at Paramatta, in New South Wales' Gives position and distance In "Ast Soc Roy Mems," vol III

287	Schwerd (Oeltzen)	1855	1 397	To 9 Mag Circumpolar	R A, Decl +70° to Pole	1828 0	Schwerd's "Beobachtungen von Circumpolarsternen in Mittleren Positionen 1828 0" In "Vienna Acad Denkschriften, 1855"
288	Herschel, J F W	1829	384	Double Stars	R A, N P D	1828 0	"Observations with a 20-ft Reflecting Telescope, 3rd Series" Gives position and distance In "Ast Soc Roy Mems," vol iii
289	Bianchi, G	1829	36	Prin Stars	Decl	1828 0	"Effemeridi Astronomiche di Milano per l'anno 1830, Milano, 1829," p 113 Made with the meridian circle of the Royal Observatory at Modena
290	Bianchi, G	1829	65	Prin Stars Circumpolar	Decl,	1825 0	In "Effemeridi Astronomiche di Milano per l'anno 1830, Milano, 1829," p 114
291	Mayer, L	1830	46	Prin Stars	N P D	1829 0	Fund Stars observed in 1828 at Vienna Observatory In 'Annalen der K K Sternwarte der Wien," vol x 1st Ser p lii
292	Mayer, L	1830	48	Prin Stars	R A, N P D	1829 0	Fund Stars observed in 1828 at Vienna Observatory In Annalen der K K Sternwarte der Wien," vol x 1st Ser p lii
293	Littrow J J	1831	45	Fund Stars	N P D	1829 0	From observations with the Vienna meridian circle in 1827, 1828, and 1829 In "Ast Soc Roy Mems,' vol iv p 328
294	Astronomical Society's Catalogue	1827	2 881	Prin Stars to 7 Mag	R A, Decl	1830 0	'Catalogue of 2,881 Principal Fixed Stars, reduced to Jan 1, 1830, computed at the expense and under the direction of the Ast Soc of London, with Tables by F Baily" Consists of stars from the Catalogues of Bradley Piazzi, and a few from Lacaille and Zach (For 'Index to the Stars in the A S C, giving the numbers according to Constellations,' by Lieut Stratford, see "Ast Soc Roy Mems,' vol v)
295	Pond, J, Ast Roy	1829	720	Prin Stars	R A N P D	1830 0	Greenwich Catalogue in "Greenwich Observations, 1829"
296	Pond, J, Ast Roy	1833	1 112	To 6 Mag	R A N P D	1830 0	A Catalogue of 1 112 Stars reduced from observations made at the Royal Observatory, Greenwich, 1816 to 1833, London 1833
297	First Cambridge Catalogue (Airy, G B Ast Roy)	1839	726	Prin Stars	R A Decl	1830 0	A Catalogue of Stars observed at Cambridge from 1828–1835 In Ast Soc Roy Mems,' vol xi
298	Argelander F G A	1835	560	To 8 Mag	R A Decl	1830 0	DLX Stellarum Fixarum Positiones Mediæ ex observationibus Aboæ habitis deduxit Helsingfors, 1835'
299	Baily F	1827	1 202	To 7 Mag	R A Decl [illegible] 10° [illegible]	1830 0	A Catalogue of all the Stars to the 7th Mag inclusive, situated within 10° of the Ecliptic, London 1827 Stars from A S C
300	[illegible]ows F (Airy	1851	[illegible]25	Prin Stars	R A N P D	183[illegible]	Results of the Observations made by the Rev F Fallows at the Royal Observatory Cape of Good Hope in the years 1829–1831 In 'Ast Soc Roy Mems vol xix

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
						A D	
301	Johnson, M J	1835	606	Prin Stars	R A, South Decl	1830 0	'A Catalogue of 606 Principal Fixed Stars in the Southern Hemisphere, deduced from Observations made at the Observatory, St Helena, from Nov 1829 to April 1833, London, 1835"
302	Pearson, William	1824	520	Zod Stars	R A, Decl 6° N & S of Ecliptic	1830 0	"Catalogue of 520 Stars within 6° North and South of the Ecliptic observed at South Kilworth" In "Ast Soc Roy Mems," vol xv
303	Wrottesley, J	1838	1,318	6 and 7 Mag	Right Ascen	1830 0	"A Catalogue of the R A s of 1,318 Stars contained in the Ast Soc s Cat' In "Ast Soc Roy Mems," vol x
304	Wrottesley, J	1842	55	6 and 7 Mag	Right Ascen	1830 0	"A Supplemental Catalogue of the R A 's of 55 Stars' In "Ast Soc Roy Mems, vol xii
305	Struve, F G W	1852	2 874	Double Stars	R A, Decl	1830 0	"Stellarum Fixarum imprimis Duplicium et Multiplicium Positiones Mediæ pro Epocha 1830 0 deductæ ex observationibus Meridianis annis 1822 ad 1843 in Specula Dorpatensi institutis, Petropoli, 1852,' p 235 General Catalogue of Double Stars
306	Struve, F G W	1852	48	Prin Stars	R A, Decl	1830 0	"Catalogi Generalis 48 loca emendata Pos Med, p cxii
307	Struve F G W.	1852		Double Stars	R A Decl	1824 1828 1832 1836 1840	"Catalogi Specialis Positionum Mediarum ad Epochas 1824 1828, 1832 1836 et 1840 Reductarum' "Pos Med p I
308	Mason E P, and Smith H L	1841	29	Telescopic	R A Decl	1830 0	In Nebula *h* 1991 In 'Amer Phil Soc Trans," vol vii N S
309	Mason E P and Smith H L	1841	37	Telescopic	R A Decl	1830 0	In Nebula *h* 2008 In 'Amer Phil Soc Trans, vol vii N S
310	Mason E P and Smith H L	1841	196	Telescopic	R A Decl	1830 0	In Nebula *h* 2092 and 2093 In Amer Phil Soc Trans, vol vii N S
311	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible] at Greenwich 1816 to 1834 [illegible]
312	[illegible]		[illegible]	[illegible]	N P D	[illegible]	[illegible] 1825 1835 [illegible] 1835
313	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]
314	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

316	Herschel J F W	1833	2,007	Double Stars	R A N P D	1830 0	"Fifth Catalogue of Double Stars observed at Slough in the years 1830 and 1831 with the 20-feet Reflector " Contains 1,304 objects not previously described Gives position and distance In "Ast Soc Roy Mems," vol vi
317	Herschel, J F W	1836	286	Double Stars	R A , N P D	1830 0	"Sixth Catalogue of Double Stars observed at Slough in the years 1831 and 1832 with the 20-feet Reflector ' Contains 105 objects not previously described Gives position and distance In "Ast Soc Roy Mems," vol ix
318	Herschel, J F W	1847	2,103	Double Stars	R A , N P D	1830 0	"Reduced Observations of Double Stars made with the 20-ft Reflector at Feldhausen C G H, in the years 1834–1838" In "Results of Astronomical Observations made during the years 1834–1838 at the Cape of Good Hope, London, 1847," p 171 Gives measurements of distance and position angle
319	Herschel, J F W	1847	417	Double Stars	R A , N P D	1830 0	"Microm Mes of Double Stars with the 7-ft Equatorial taken at Feldhausen, C G H ' In ditto p 276 Gives distance and position angle
320	Herschel, J F W	1847	44	Telescopic Stars	Diff R A Decl	1830 0	In Cluster 17 *Messier* In ditto, p 9
321	Herschel, J F W	1847	27	Telescopic Stars	Diff R A , Decl		Nebula IV H 41 In ditto, p 11
322	Herschel, J F W	1847	26	Telescopic Stars	Diff R A , Decl	.	Nebula V H 30 In ditto, p 12
323	Herschel, J F W	1847	105	Telescopic Stars	Co-ordinates from Star	.	Nebula 30 (Bode) *Doradus* In ditto, p 13
324	Herschel, J F W	1847	186	Telescopic Stars	Diff R A , Decl.		Nebula 8 *Messier* In ditto, p 16
325	Herschel, J F W	1847	110	Telescopic Stars	Diff R A Decl		Cluster about *κ Crucis* In ditto, p 17
326	Herschel, J F W	1847	150	Telescopic Stars	Diff R A , Decl		Nebula *θ Orionis* In ditto, p 28
327	Herschel, J F W	1847	1 216	Telescopic Stars	Diff. R A , Decl		Nebula about *η Argûs* In ditto, p 42
328	Herschel, J F W	1847	244	Stars and Nebulæ	R A , N P D	1830 0	Stars Clusters, and Nebulæ in the "Nubecula Minor ' In ditto, p 153
329	Herschel, J F W	1847	919	Stars and Nebulæ	R A , N P D	1830 0	In "Nubecula Major In ditto, p 156
330	Herschel, J F W	1847	76	Ruby Stars	R A , N P D	1830 0	Approximate Places of 76 Ruby Coloured or very intensely Red Insulated Stars noticed in the course of observation in either Hemisphere " In ditto, p 448
331	Herschel, J F W	1871	336	Double Stars	R A N P D	1830 0	"Seventh Catalogue of Double Stars observed at Slough in the years 1823–28 inclusive with the 20-ft Reflector Contains 84 objects not previously described Gives position and distance In "Ast Soc Roy Mems vol xxxviii

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
332	Herschel, J F W (Main and Pritchard)	1874	10,317	Double Stars	R A , N P D	A D 1830 0	"A Catalogue of 10,300 Multiple and Double Stars arranged in the order of R A by the late Sir J F W Herschel, Bart , edited by the Rev R Main and the Rev C Pritchard" In "Ast Soc Roy Mems ," vol xl Places only Gives no measurements
333	Denison, Lieut	1842	158	Prin Stars	R A , Decl	1830 to 1838	"Ordnance Survey Astronomical Observations made with Ramsden's Zenith Sector, London, 1842" The R A and Decl are for the epochs placed against each star
334	Henderson, T	1833	7	Near South Pole	R A , Decl	1832 0	"On the Positions of several Stars near the South Pole" In "Ast Soc Roy Mems ," vol vi
335	Henderson, T	1838	172	Prin Stars 125 Southern 47 Northern	Declinations	1833 0	"On the Declinations of the Principal Fixed Stars, deduced from Observations made at the Observatory, Cape of Good Hope in the years 1832 and 1833" In 'Ast Soc Roy Mems ," vol x
336	Henderson, T	1846	174	Prin Stars 125 Southern, 49 Northern	R A	1833 0	"The Right Ascensions of the Prin Fixed Stars deduced from Observations made at the Observatory, Cape of Good Hope, in the years 1832 and 1833" In "Ast Soc Roy Mems ," vol xv
337	Pond, J , Ast Roy		66	Prin Stars	N P D	1833 0	"Catalogue of the N P D s of 66 Principal Stars from the latest Observations at Greenwich" Made from 33,410 observations In "Greenwich Observations, 1833"
338	Dawes, W R	1835	121	Double Stars	R A , Decl	1834 0	'Micrometrical Measurements of the Positions and Distances of 121 Double Stars taken at Ormskirk during the years 1830–1833' Gives position and distance In 'Ast Soc Roy Mems ," vol viii
339	Madras Catalogue (Taylor)	1844	11 015	To 8 Mag	R A , Decl	1835 0	"A General Catalogue of the Principal Fixed Stars from Observations made at the Hon E I Co 's Observatory at Madras in the years 1830–1843, by Thos Glanville Taylor, Madras 1844'
340	San Fernando Catalogue (Montojo S)	1842	126		R A , Decl	1835 0	'Mean Positions of the Stars contained in 'Mr Baily s Address as determined at San Fernando in 1834–1838' In 'Ast Soc Roy Mems , vol xii
341	Rumker, C	1843	11 978	To 9 Mag	R A , Decl	1836 0	"Mittlere Oerter von 12,000 Fix-Sternen für den Anfang von 1836 abgeleitet aus den Beobachtungen auf der Hamburger Sternwarte, Hamburg, 1843"
342	Rumker, C	1841	60	*Pleiades*	R A Decl	1836 0	In 'Ast Nach ,' No 432
343	Carlini F	1851	38	Prin Stars Circumpolar	Declinations	1837 0	Nuova determinazione della rifrazione ' In "Effem Ast Milano, 1852 Appendix
344	Koller M	1842	208		R A Decl	1838 0	'Catalogue of 208 Stars,' made at the Observatory at Kremsmunster In 'Ast Soc Roy Mems ," vol xii

345	Armagh Catalogue	1859	5,345	To 9 Mag	R A , Decl	1840 0	' Places of 5,345 Stars observed from 1828 to 1854, at the Armagh Observatory, by the Rev T R Robinson, Dublin, 1859"
346	Bessel, F W	1841	53	*Pleiades*	R A , Decl	1840 0	Positions of the *Pleiades* determined from measurements with the Konigsberg heliometer In " Astronomische Untersuchungen, Konigsberg, 1841 "
347	Bessel, F W	1841	62	Fund Stars	Decl	1840 0	In " Ast Nach ," No 422
348	Argelander, F G A	1843	3,256	Visible Stars	R A , Decl	1840 0	" Uranometria Nova, Stellæ per Mediam Europam Solis oculis conspicuæ secundum veras lucis Magnitudines e cœlo ipso descriptæ, Berolini, 1843 "
349	Behrmann, C	1874	2,344	Visible Stars	R A , Decl	1840 0	" Atlas des Sudlichen Gestirnten Himmels Darstellung der zwischen dem Sudpol und dem 20-Grad Sudlicher Abweichung mit blossen Augen sichtbaren Sterne nach ihren wahren, Leipzig, 1874 "
350	Bianchi, G	1846	220	Prin Stars	R A , Decl	1840 0	" Posizioni Medie delle 220 Stelle Principali di Piazzi " In " Modena Ital Soc Mem ," vol xxiii , Parte Matematica
351	Airy, G B, Ast Roy (Greenwich Catalogue)	1843	1,439	To 8 Mag	R.A , N P D	1840 0	" Catalogue of the Places of 1,439 Stars referred to the 1st of January 1840, deduced from the Observations made at the Royal Observatory, Greenwich, from 1836, January 1, to 1841, December 31, London, 1843 "
352	Lamont, J	1847	3,676	Small Stars	R A , Decl Zone − 0° to − 10°	1840	" Observationes Astronomicæ in Specula Regia Monachiensi institutæ, Monachii, 1847," vol xv
353	The Bedford Catalogue (Smyth, W H)	1844	850	Double Stars, Nebulæ, and Clusters	R A , Decl	1840 0	" A Cycle of Celestial Objects for the use of Naval, Military, and Private Astronomers, observed, reduced, and discussed, by Capt W H Smyth, London 1844 " Vol ii consists of— Double Stars 419 | Quadruple Stars 13 Stars and Comites 161 | Multiple Stars 21 Binary Stars 20 | Nebulæ 98 Triple Stars 46 | Clusters 72 Gives micrometric measurements of distance and position angle
354	Jacob, W S	1849	244	Double Stars	R A , Decl	1840 0	" Catalogue of Double Stars, deduced from Observations made at Poona from November 1845 to February 1848 " Gives position and distance In " Ast Soc Roy Mems ," vol xvii
355	Santini, G	1840	4,092	To 9 Mag	R A , Decl + 11° to − 11°	1840 0	Descrizione del Circolo Meridiano dell I R Osservatorio di Padova, Padova, 1840 ' In ' Padova Accad Nuovi Saggi,' vols v and vi
356	Santini, G	1842	1,677	To 9 Mag	R A Decl + 0° to + 10°	1840 0	' A Catalogue of 1,677 Stars included between the Equator and 10° of North Decl , observed at the Royal Observatory of Padua " Catalogue made to establish a series of reference points for extra-meridional observations of Planets and Comets In " Ast Soc Roy Mems ,' vol xii

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places Co ordinates	Epoch	Notes
357	Gilliss, J M (Washington Catalogue)	1846	1,248	To 7 Mag	R A, Decl	A D 1840 0	'Astronomical Observations made at the Naval Observatory, Washington, Washington, 1846" Catalogue made from observations, October 1838 to July 1842
358	Struve, F G W	1843	514	Double Stars	R A, Decl	1840 0	"Catalogue de 514 Etoiles Doubles et Multiples découvertes sur l'Hémisphère Céleste Boréale par la grande lunette de l'Observatoire centrale de Poulkova, et Cat de 256 Étoiles Doubles Principales ou la distance des composantes est de 32 sec à 2 minutes, St -Pétersbourg, 1843"
359	Struve, F G W	1843	256	Double Stars	R A, Decl	1840 0	
360	Dawes, W R	1851	98	Double Stars	R A, N P D	1840 0	"Micrometrical Measurements of Double Stars made at Ormskirk between 1834 0 and 1839 4" Gives position and distance In "Ast Soc Roy Mems," vol xix
361	Argelander, F W A	1846		To 9 0 Mag	R A Decl +45° to +80° in zones	1842 0	"Durchmusterung des Nordlichen Himmels, zwischen 45 und 80 Grad der Declination auf der Interims Sternwarte der Kong Rh F W Universitats zu Bonn in den Jahren 1841 bis 1844 ausgefuhrt, Bonn, 1846" Unreduced
362	Argelander (Oeltzen)	1851 & 1852	26,425	To 9 0 Mag	R A Decl +45° to +80°	1842 0	"Argelander's Zonen-Beobachtungen vom 45 bis 80 Grad Nordlicher Declination in Mittleren Positionen fur 1842 0 nach gerader Aufsteigung geordnet von W Oeltzen" Zones reduced and arranged in order of R A In 'Wien Annalen K K Sternwarte," vols i & ii, 3rd series
363	Cooper, E J, and Graham A	1844	50	Telescopic Stars	R A Decl +88° to Pole	1842 0	"Mean Places for 1 January 1842 of 50 Telescopic Stars within 2° N P D observed in the years 1842 and 1843 at Markree, in the county of Sligo" In "Ast Nach," No 490
364	Santarelli	1842	104	Double Stars	R A Decl	1842 0	"Memoria intorno a parecchie Osservazioni fatte nella Specola dell Univ Gregor in Collegio Romano, Roma, 1842' Gives measurements of position and distance
365	Bessel (Luther E)	1859	36	Fund Stars	Declinations	1843 0	'Declinationes Stellarum Fundamentalium a Besselio" In "Konigsberg Observations,' vol xxxiii p 115, "Dissertatio Konigsberg, 1859, and 'Ast Nach,' No 1,076
366	Airy G B, Ast Roy	1852	491	Prin Stars	Decl +37° to +70°	1843 0	Prepared from Greenwich Observations In 'Ordnance Survey Astronomical Observations made with Airy's Zenith Sector 1842 to 1850, for the Determination of the Latitudes of various Trigonometrical Stations, London, 1852
367	Santarelli	1843	415	Prin Stars	R A Decl	1844 0	'Osservazioni fatte nella Specola dell Univ Gregoriana in Collegio Romano, Roma 1843 p 103

368	Santarelli	1843	100	Prin Stars	R A , Decl	1844 0	In "Osservazioni fatte nella Specola dell' Univ Gregoriana in Collegio Romano, Roma, 1843," p 103
369	Greenwich 12-yr Catalogue (Airy, G B , Ast Roy)	1849	2,156	To 9 Mag	R A , N P D	1845 0	"Catalogue of 2,156 Stars, formed from the Observations made during 12 years, from 1836 to 1847, at the Royal Observatory, Greenwich" Formed from two separate Catalogues made from observations in the years 1836 to 1841 and 1842 to 1847 The Catalogues kept distinct, reduced to their mean Epochs 1840 and 1845 respectively App to "Greenwich Observations, 1847"
370	The Radcliffe Catalogue (Johnson, M J)	1860	6,317	To 9 Mag	R A , Decl	1845 0	"The Radcliffe Catalogue of 6 317 Stars, chiefly Circumpolar reduced to the Epoch 1845 0, formed from the Observations made at the Radcliffe Observatory, under the Superintendence of M J Johnson, Introduction by Rev R Main, Oxford, 1860'
371	Madras Catalogue		97	Prin Stars	R A , Decl	1845 0	"Catalogue of 97 Principal Fixed Stars, from Observations made at the Madras Observatory in the years 1843–1847," Appendix to "Madras Observations,' vol vi
372	Maclear, T	1866	105	Zenith Stars	R A , N P D	1845 0	Observed with Bradley's zenith sector at the Cape of Good Hope "In Verification of Lacaille s Arc of Meridian," vol ii p 439
373	Poulkova Catalogue (Struve, O)	1869	374	Prin Stars	R A	1845 0	"Ascensions Droites Moyennes des Étoiles Principales" In "Observations de Poulkova," vol i p (120)
374	Poulkova Catalogue (Struve, O)	1870	300	To 9 Mag	R A	1845 0	"Ascensions Droites Moyennes des Étoiles observées occasionellement ' "Observations de Poulkova," vol iii p (161)
375	Poulkova Catalogue (Struve, O)	1870	38	Fund Stars	R A	1845 0	In "Observations de Poulkova,' vol iii p (42)
376	Poulkova Catalogue (Struve, O)	1872	374	Prin Stars	Decl	1845 0	"Declinaisons Moyennes des Étoiles Principales" In "Observations de Poulkova,' vol iv p (50)
377	Poulkova Catalogue (Struve, O)	1872	59	To 9 Mag	Decl	1845 0	"Déclinaisons des Étoiles observées occasionellement" In "Observations de Poulkova,' p (71)
378	Wolfers		44	Fund Stars	R A	1845 0	"Vergleichung der Rectascensionen in den 'Tabb Red,' mit den Beobachtungen in Pulkowa" "Ast Nach, 1790'
379	Wolfers		22	Nebensterne	R A	1845 0	'Vergleichung der Rectascensionen in den 'Tabb Red, mit den Beobachtungen in Pulkowa ' "Ast Nach, 1790"
380	Le Verrier U J	1856	36	Fund Stars	R A , Decl	1845 0	"Positions des Étoiles Fondamentales" Table V contains Mean Positions of 36 Fund Stars for every 10 years from 1750 to 1900 In 'Annales de l'Observatoire Imp de Paris,' vol ii, Paris, 1856
381	Maclear, T	1849	18	Southern Stars	R A Decl	1847 0	' Observations of Southern Stars made at the request of Prof Madler In "Ast Soc Roy Mon Nots,' vol ix p 16

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
382	Wichmann, M	1849	160	6 to 10 Mag	R A , Decl	A D 1848 0	"Verzeichniss von 160 Vergleichsternen zu den Beobachtungen am Konigsberger Heliometer" In "Ast Nach," No 694
383	Oudemanns, J A C	1852	86	Prin Stars	R A , Decl	1849 0	"Dissertatio Astronomica inauguralis, Lugduni-Batavorum, 1852" Catalogue consists of stars in the Catalogues of Argelander (560), Greenwich, Cambridge, Edinburgh, Radcliffe, and Konigsberg, all reduced to Epoch 1849 0 and the mean place of all the catalogues adopted
384	Oudemanns, J A C	1852	101	Prin Stars	Declinations	1849 0	In "Dissertatio Astronomica inauguralis, Lugduni-Batavorum, 1852," Tab 12 From observations with the vertical circle
385	British Association Catalogue (Baily, F)	1845	8,377	To 8 Mag	R A , N P D	1850 0	"The Catalogue of Stars of the British Association for the Advancement of Science, London, 1845" Compiled from the following catalogues — 1 All Bradley's 3,222 stars and Lacaille's 1,942 stars 2 Other stars in the Catalogues of Hevelius, Flamsteed, Mayer, Pond, Argelander, Rumker, Johnson 3 Other stars in the following catalogues not less than 6 mag wherever situate nor less than 7 mag if within 10° of Ecliptic Piazzi, Zach Wollaston, Groombridge, Brisbane Airy, Taylor, Lacaille (new) 4 Other stars possessing any special peculiarities
386	Greenwich 6-year Catalogue (Airy, G B Ast Roy)	1856	1,576	To 9 Mag	R A , N P D	1850 0	"Catalogue of 1,576 Stars, formed from the Observations made during six years from 1848 to 1853 at the Royal Observatory, Greenwich, London, 1856" Appendix II to "Greenwich Observations, 1854"
387	Durham Observatory (Carrington, R C)	1855	195		R A , Decl	1850 0 and 1851 0	' Results of Astronomical Observations made at the Observatory at the University of Durham from Oct 1849 to April 1852, Durham, 1855"
388	Washington Zones (Transit)	1873	12,033	To 10 Mag	R A , Decl - 9° to −41° In Zones	1850 unreduced	"Zones of Stars observed at the U S Naval Observatory with the Meridian Transit Instrument in the years 1846–49" "Washington Observations, 1870"
389	Washington Zones (Mural)	1872	14,804	To 10 Mag	R A , Decl - 4° to −40° In Zones	1850 unreduced	"Zones of Stars observed at the U S Naval Observatory with the Mural Circle in the years 1846–49 ' In "Washington Observations, 1869 '
390	Madras Catalogue (Jacob)	1854	1 440	To 7 Mag	R A , N P D	1850 0	"A Subsidiary Catalogue of 1,440 Stars selected from the B A C , from Observations made at Madras in the years 1849–53, Madras 1854 In 'Madras Observations 1848–52

391	Markree Catalogue (Cooper, E J)	1851–56	60,155	To 12 Mag	R A , Decl near Ecliptic	1850 0	'Catalogue of 60 155 Stars near the Ecliptic, observed at Markree during the years 1848–56, and whose places are supposed to be hitherto unpublished, Dublin, 1851–56 Subdivided into separate catalogues for each month's observations Stars are not numbered, and their identification is difficult
392	Madras Catalogue (Jacob, W S)	1854	97	Prin Stars	R A., N.P.D	1850 0	Mean Places of 97 Prin Fixed Stars from Observations at the Madras Observatory, 1848–52" In "Madras Observations, 1848–52"
393	Bradley (Madler)	1856	3,222	To 8 Mag	R A (in Degrees), Decl (in Zones)	1850 0	'Die Eigenbewegungen der Fixsterne in ihrer Beziehung zum Gesammtsystem von J H Madler, Dorpat, 1856" "Catalog der 3,222 Bradley'schen Sterne aus sammtlichen altern und neuern Meridianbeobachtungen" Arranged in 4 Zones (1) All stars south of the Equator (2) 0° to +30°, (3) +30° to +60°, (4) +60° to Pole "Dorpat Observations" vol xiv p 14 The Catalogue arranged in order of R A (in Time) at p 265
394	Rumker, C	1859	3,126	To 9 Mag	R A 0 H to VII H , Decl	1850 0	"Neue Folge der Mittleren Oerter von Fixsternen fur den Anfang von 1850 abgeleitet aus dem Beobachtungen auf der Hamburger Sternwarte, Hamburg, 1859"
395	Munich Catalogue (Lamont J)	1874	2,112	Small Stars Mags not given	R A Decl	1850 0	"Annalen der Konig Sternwarte bei Munchen auf offentliche Kosten herausgegeben von Dr J Lamont, Munchen, 1874,' vol xx
396	Munich Zone Catalogue (Lamont J)	1866	9 412	8 to 10 Mag	R A Decl −3° to −3°	1850 0	Annalen der Konig Sternwarte bei Munchen, Munchen, 1866–74" Supplemental vol v
397	Munich Zone Catalogue (Lamont J)	1869	6 323	8 to 10 Mag	R A Decl −3° to −9°	1850 0	Ditto, Supplemental vol viii
398	Munich Zone Catalogue (Lamont J)	1869	4 793	8 to 10 Mag	R A Decl −3° to −9°	1850 0	Ditto, Supplemental vol ix
399	Munich Zone Catalogue (Lamont, J)	1871	3 571	8 to 10 Mag	R A Decl +9° to +15°	1850 0	Ditto, Supplemental vol xi
400	Munich Zone Catalogue (Lamont J)	1872	4 093	8 to 10 Mag	R A Decl −9° to −15°	1850 0	Ditto Supplemental vol xii
401	Munich Zone Catalogue (Lamont, J)	1874	1 818	8 to 10 Mag	R A Decl +15° to +21°	1850 0	Ditto, Supplemental vol xiii
402	Munich Zone Catalogue (Lamont J)	1874	630	8 to 10 Mag	R A Decl +21° to −27°	1850 0	Ditto Supplemental vol xiii
403	Munich Zone Catalogue (Lamont J)	1874	1 621	8 to 10 Mag	P A Decl −15° to −21°	1850 0	Ditto Supplemental vol xiii
404	Munich Zone Catalogue (Lamont J)	1874	904	8 to 10 Mag	R A Decl −21° to −27°	1850 0	Ditto Supplemental vol xiii

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
						A D	
405	Munich Zone Catalogue (Lamont, J)	1874	591	8 to 10 Mag	R A , Decl −27° to −33°	1850 0	"Annalen der Konig Sternwarte bei Munchen, Munchen, 1866–74" Supplemental vol xiii
406	Munich Zone Catalogue (Lamont, J)	1874	918	8 to 10 Mag	R A , Decl +15° to −15°	1850 0	Ditto Addition to former Catalogue
407	Munich Zone Catalogue (Lamont, J)	1874	2,548	8 to 10 Mag	R A , Decl +15° to −15°	1850 0	Ditto Addition to former Catalogue
408	Bessel, F W	1830	38	Fund Stars	R A , Decl	1750 0 to 1850 0	"Tabulæ Regiomontanæ reductionum observationum Astronomicarum ab anno 1750 usque ad annum 1850 computatæ Regiomonti, 1830"
409	Newcomb, S	1872	32	Fund Stars	Right Ascen	1750 0 to 1850 0	"On the Right Ascensions of the Equatorial Fundamental Stars and the corrections necessary to reduce the R A s of different catalogues to a mean homogeneous system, Washington, 1872" In "Washington Observations, 1870," Appendix III
410	Santiago Catalogue (Gilliss)	1871	1 963 290	To 9 Mag Double Stars	R A , S Decl	1850 0	"A Catalogue of 1,963 Stars and of 290 Double Stars observed by the United States Naval Astronomical Expedition to the Southern Hemisphere during the years 1850, 51, 52 From observations at Santiago Washington, 1871" Appendix to "Washington Observations, 1868"
411	Wrottesley, Lord		1 009	6 and 7 Mag	Right Ascen	1850 0	"A Catalogue of the R A s of 1,009 Stars contained in the B A C" In "Ast Soc Roy Mems," vol xxiii
412	Argelander, F W A	1852		To 9 0 Mag	R A , Decl in zones	Unreduced	"Durchumusterung der Himmelzone zwischen 15 und 31 Grad Sudlicher Declination, auf der Sternwarte der Konig Rh F W Univ zu Bonn in den Jahren 1849–1852, Bonn, 1852" Zones unreduced
413	Argelander (Oeltzen)		23,250	To 9 Mag	R A , S Decl	1850 0	"Argelanders Zonen Beobachtungen vom 15 bis 31 Grade Sudlicher Declination in Mittleren Positionen fur 1850 0" Reduced and arranged in order of R A by W Oeltzen In "Vienna Acad Sitzungsberichte," vols xxvi xxvii xxix and xxxi
414	Argelander, F W A	1867	2 920	To 9 5 Mag	R A , S Decl −14° 40′ to −31° 20′	1850 0	"Mittlere Oerter von 33,811 Sternen, abgeleitet aus den am Meridiankreise der Bonner Sternwarte" "Bonner Beobachtungen,' vol vi, Bonn, 1867, p 335
415	Epps J	1851	148	Prin Stars	R A	1850 0	Catalogue of Stars made at the Hartwell Observatory In Smyth, "Ædes Hartwellianæ,' and 'Speculum Hartwellianum'

416	"Almanac Catalogue" (Downes, J)	1864	1,078	Zodiacal Stars, to 7 Mag	R A , Decl	1850 0	"Almanac Cat of Zodiacal Stars, printed for the use of the American Ephem and Naut Alm, Washington, 1864" Compiled from Greenwich 12-year Cat, B A C, Oeltzen's Argelander (Southern), Rumker, Lalande, and Weisse's Bessel
417	Madler, J H	1850	663	Double Stars	R A , Decl	1850 0	"Uebersichts Tafel der Doppelsterne von erkannter Bewegung, Dorpat, 1850" Stars from Struve's "Mens Microm" In 'Beobachtungen der K Univ Sternwarte, Dorpat," vol xii
418	Bishop, G	1852	252	Double Stars	R A , N P D	1850 0	"Astronomical Observations taken at the Observatory, South Villa, Regent's Park, London, during the years 1839–1851, London, 1852" Cat made chiefly by W R Dawes
419	Fletcher, J	1854	51	Double Stars	R A , N P D	1850 0	"Results of Micrometrical Measures of Double Stars made at Tarn Bank, Cumberland, from 1850 2 to 1853 4" In "Ast Soc Roy Mems," vol xxii
420	Dawes, W R	1867	240	Double Stars	R A , N P D	1850 0	"Catalogue of Micrometrical Measurements of Double Stars" In "Ast Soc Roy Mems," vol xxxv
421	Jacob, W S	1854	144	Double Stars	R A , N P D	1850 0	'Observations of 144 Double or Multiple Stars made at the Madras Observatory with the Lerebours Equatoreal in 1850–52'
422	Jacob, W S	1854	106	Double Stars	R A , N P D	1850	"Catalogue of 106 Double Stars observed with the Lerebours Equatoreal"
423	Struve, Otto	1853	514	Double Stars	R A , Decl	1850 0	'Catalogue revu et corrige des Etoiles Doubles et Multiples decouvertes a l'Observatoire centrale de Poulkova" In "St-Petersbourg Acad Mems," vol vii, 1853
424	Sabler (Struve, W)	1852	175		R A , Decl	1851 0	'Catalogus continens 175 Stellarum Positiones Medias ad 1851 00 ex Observationibus Pulcovensibus reductas" In 'Stel Fix Dup et Mult Pos Med,' p 351
425	Laugier, E	1860	105	Fund Stars	N P D	1852 0	"Mémoire sur la détermination des Distances Polaires des Étoiles Fondamentales' In "Acad des Sciences Mems," vol xxvii pt 2
426	Laugier, E	1860	84	Not Fund Stars	N P D	1852 0	
427	Laugier, E	1860	140	Fund Stars	N P D	1852 0	"Determination des Distances Polaires et des mouvements propres normaux de 140 Étoiles Fondamentales' In "Comptes Rendus,' vol xliv, also in "Acad des Sciences Mèms,' vol xxvii pt 2
428	Chacornac Ecliptic Charts of the Paris Observatory		62 604	To 13 Mag	R A Decl	1852 5	Atlas Ecliptique (not completed) 36 Maps Nos 1 to 6, 9, 13, 15, 22, 26 to 30, 34 to 36, 39, 41, 46 49 to 52 61 to 64A, 70 to 72 In Charts No Catalogue
429	Harvard Zones (Bond W C)	1855	5 500	To 12 Mag	R A Decl −0° to +0° 20′	Unreduced	Annals of the Astronomical Observatory of Harvard College, vol 1 part 2 From observations in 1852 and 1853 Cambridge (Mass) 1855

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Coordinates	Epoch	Notes
						A D	
430	Harvard Zones (Bond, W C)	1867	4,484	To 12 Mag	R A , Decl +0° 20′ to +0° 40′	Unreduced	"Annals of the Astronomical Observatory of Harvard College,' vol ii pt 2 From observations in 1854 and 1855 Cambridge (Mass), 1867
431	Bond, W C	1855	1,123	Standard Stars	R A , Decl +0° to +1°	1853 0	"Standard Catalogue of Stars between the Equator and 1° of North Declination" In "Annals of the Ast Obs of Harvard College,' vol i pt 2
432	Red-Hill Catalogue (Carrington, R C)	1857	3,735	To 10 Mag Circumpolar	R A , Decl +81° to the Pole	1855 0	"A Catalogue of 3,735 Circumpolar Stars, observed at Red-Hill in the years 1854, 55, 56 London, 1857'
433	Red Hill Catalogue (Carrington, R C)	1857	19	Stars very near the Pole	R A	1855 0	Positions determined by special method In "A Catalogue of 3,735 Circumpolar Stars, observed at Red-Hill in the years 1854, 55, 56 London, 1857"
434	"Bonner Sternverzeichniss" (Argelander, F W A)	1859	110,984	To 9 5 Mag	R A , Decl − 2° to +20° in Zones of 1°	1855 0	"Bonner Sternverzeichniss Erste Section enthaltend die genaherten Mittleren Oerter von 110,984 Sternen zwischen 2 Grad Sudlicher und 20 Grad Nordlicher Declination, Bonn, 1859"
435	' Bonner Sternverzeichniss" (Argelander, F W A)	1861	105,075	To 9 5 Mag	R A , Decl +20° to +41°	1855 0	"Bonner Sternverzeichniss zweiter Section, Bonn, 1861"
436	"Bonner Sternverzeichniss" (Argelander, F W A)	1862	108,129	To 9 5 Mag	R A , Decl +41° to +90°	1855 0	"Bonner Sternverzeichniss Dritte Section, Bonn, 1862"
437	"Bonner Sternverzeichniss" (Argelander, F W A)	1867	30 891	To 9 5 Mag	R A , Decl − 1° to +90° and − 2° to −14° 40′ in Zones of 1°	1855 0	"Mittlere Oerter von 33,811 Sternen abgeleitet aus den am Meridiankreise der Bonner Sternwarte in den Jahren 1845–1867 angestellten Beobachtungen und in drei Verzeichnissen zusammengestellt, Bonn, 1867'
438	Heis E	1872	5,421	Visible Stars	R A Decl	1855 0	"Atlas Cœlestis Novus Stellæ per Mediam Europam solis oculis conspicuæ secundum veras lucis magnitudines e cœlo ipso descriptæ Coloniæ ad Rhenum 1872"
439	Calandrelli J	1855	60	Prin Stars	R A Decl	1855 0	' Catalogo delle Stelle osservate ' In Roma Accad Pont Nuovi Lincei Atti" vol vi p 317
440	Gould B A	1862	48	Circumpolar	R A , Decl	1855 0	"On the Mean Places for 1855 0 of 48 Circumpolar Stars In Gould's Ast Jour , vol vi p 78
441	Gould, B A	1867	4	Polar Stars	R A , Decl	1855 0	In ' U S Coast Survey 1865 Gives places also for Epochs 1790 to 1870

442	Gould, B A	1867	132	Time Stars	Decl	1855 0	"Declinations of Standard Time Stars" "U S Coast Survey 1865," p 152
443	Krueger, A	1865	43	Small Stars	R A , Decl	1855 0	"Der Sternhaufen *h Persei* Beobachtungen desselben am Bonner Heliometer nebst deren Berechnung, Helsingfors, 1865" Stars in the Cluster 33 H vi In "Finnischen Soc Abhand"
444	Santiago Catalogue (Moesta C G)	1859	999		R A , South Decl	1855 0	'Observaciones Astronomicas hechas en el Observatorio Nacional de Santiago de Chile en los años de 1853, 54, 55, Santiago de Chile, 1859"
445	Safford, T H	1863	127	Clock Stars	R A	1855 0	"A Catalogue of Standard Polar and Clock Stars for the reduction of Observations in R A , with a discussion of their positions" In "American Acad Mems" vol viii N S , and "Annals of Harvard College," vol iv pt 1
446	Jacob, W S	1860	317		R A , Decl	1855 0	"Catalogue of 317 Stars selected from the B A C (being such as were supposed to have large Proper Motions) from observations at Madras in the years 1853-7" In "Ast Soc Roy Mems" vol xxviii
447	Schjellerup, H C F C	1867	6,943	Comparison Stars	R A Decl	1855 0	Genaherte Oerter der Fixsterne von welchen in den Ast Nach Band 1-66 selbstandige Beobachtungen angefuhrt sind" Gives a reference to the volume and page of the "Ast Nach" where each star is to be found In "Ast Gesell Pub der, Leipzig," No 8
448	Schjellerup, H C F C	1874	404	Red Stars	R A , Decl	1855 0	"Zweiter Catalog der rothen, isolirten Sterne" In "Ast Gesell , Viertel, 1874" p 252
449	Schonfeld E and Winnecke A	1868	126	Variable Stars	R A , Decl	1855 0	In 'Ast Gesell Viertel, 1868, p 74
450	Schonfeld E	1875	143	Variable Stars	R A , Decl	1855 0	"Zweiter Catalog von Veranderlichen Sternen Mannheim 1875"
451	Johnson M J	1856	164	Circumpolar	R A , N P D +84° to Pole	1855 0	'Catalogue of 164 Stars within 6° of the North Pole from Observations in the years 1840-1855" In "Radcliffe Observations, 1855'
452	Powell E B	1857	130	Double Stars	R A , N P D	1855 0	Observations of Double Stars taken at Madras in 1853, 4, 5, 6' In "Ast Soc Roy Mems,' vol xxv
453	Powell E B	1864	56	Double Stars	R A N P D	1855 0	Second Series of Observations of Double Stars taken at Madras in 1859-62" In "Ast Soc Roy Mems,' vol xxxii
454	Quetelet, Er	1861	343	Prin Stars	R A	1856 0	Essai sur le Mouvement Propre en Ascension Droite de quelques Étoiles" In "Belgium Acad Roy Mems,' vol xxxii
455	Vienna Zones (Littrow)		26 006	To 11 Mag	R A Decl +15° to +10°	1856 to 1858 unreduced	'Annalen der K K Sternwarte in Wien' vols vii to xxiv

No	Name.	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
456	Bond, G P	1867	1,101	To 15 Mag *Orion* Nebula	Differences, R A, & Decl	A D 1857 0	Stars near θ *Orionis*, to which positions are referred In "Annals of Harvard Coll Observatory," vol v, Cambridge (Mass), 1867
457	Struve, O, & Lapounov	1863	155	To 13 Mag *Orion* Nebula	Differences, R A, and Decl		"Observations de la Grande Nebuleuse d'*Orion*" "Petersburg, St, Acad Imp Sci Mems," 7th Ser, vol v
458	Safford, T H	1863	532	Zenith Stars	Decl	1859 0	"A Catalogue of the Declinations of 532 Stars culminating near the Zenith of the Observatory of Harvard College, Cambridge (Mass)" In "American Acad Mems," vol viii N S
459	Greenwich 7 year Catalogue (Airy, G B, Ast Roy)	1864	2,022	To 9 Mag	R A, N P D	1860 0	"Seven-year Catalogue of 2,022 Stars, deduced from Observations extending from 1854 to 1860, at the Royal Observatory, Greenwich" In "Greenwich Observations, 1862," App I
460	Second Radcliffe Catalogue (Main, R)	1870	2 386	To 9 Mag	R A, Decl	1860 0	"Second Radcliffe Catalogue, containing 2,386 Stars deduced from Observations extending from 1854 to 1861, Oxford, 1870"
461	The Cape Catalogue (Stone, E J)	1873	1,159	To 11 Mag	R A, N P D	1860 0	"The Cape Catalogue of 1,159 Stars, deduced from Observations (by Sir Thomas Maclear) at the Royal Observatory, Cape of Good Hope, 1856 to 1861, Cape Town 1873"
462	Williamstone Catalogue (Ellery, R L J)	1869	546	Mostly Prin Stars	R A, N P D	1860 0	Made from observations at the Williamstone Observatory, in 1861, 1862, and 1863 In "Astronomical Observations made at the Williamstone Observatory, Melbourne, 1869," vol i p 104
463	Capelli, G	1864	661	To 8 Mag	R A, Decl −15° to −25°	1860 0	"Posizioni Medie di 661 Stelle, distribuite nella zona fra 15° e 25° di Decl Australe" From Observations at the Milan Observatory in the years 1852, 1853, 1855, 1856 In "Effem Ast di Milano, 1865,' Appendix
464	Padua Zone Catalogue (Santini, G)	1858	2,706	To 10 Mag	R A, Decl −10° to −12° 30′	1860 0	"Posizioni Medie di 2,706 Stelle pel 1° Gennajo 1860, dedotte dalle osservazioni fatte negli anni 1856–58, nell' I R Osservatorio di Padova, Venezia, 1858" In "Memorie dell' Istituto," vol vii
465	Padua Zone Catalogue (Santini, G)	1862	2,246	To 10 Mag	R A, Decl −12° 30′ to −15°	1860 0	"Posizioni Medie di 2,246 Stelle, dedotte dalle osservazioni fatte dal Sig Trettenero negli anni 1857–61, Venezia, 1862" In 'Memorie dell' Istituto," vol x
466	Padua Zone Catalogue (Santini, G)	1870	1 425	To 10 Mag	R A, Decl −0° to −3°	1860 0	"Posizioni Medie di 1,425 Stelle, dedotte dal osservazioni fatte dal defunto Prof Trettenero, 1861–63, Venezia, 1870' In 'Memorie dell' Istituto," vol xv

467	Washington Catalogue (Yarnall, M)	1873	10,658	To 9 Mag	R A , Decl	1860 0	"Catalogue of 10,658 Stars observed at the United States Naval Observatory during the years 1845 to 1871, prepared for publication by Prof M Yarnall, Washington, 1873" Appendix III to "Washington Observations for 1871"
468	Laugier, E	1860	155	Prin Stars	Decl	1860 0 to 1870 0	"Mémoire sur la Détermination des Distances Polaires des Étoiles Fondamentales" "Acad des Sciences Mems," vol xxvii
469	Schjellerup, H C	1866	280	Red Stars	R A , Decl	1860 0	"Catalog der rothen isolirten Sterne, welche bis zum Jahre 1866 bekannt geworden sind ' In "Ast Nach" No 1591
470	Schmidt, J F Julius	1873	162	Orange-red Stars	R A , Decl	1860 0	'Ueber die Farben der Fixsterne" In "Ast Nach" No 1902
471	Yarnall, M	1873	51	Prin Stars	R A , Decl	1860 0	"Positions of the Principal Stars derived from Observations made at the U S Naval Observatory, Washington, in the years 1853 to 1860" In "Ast Nach,' No 1947
472	Stone, E J	1874	8	Close to South Pole	R A , N P D	1860 0 to 1900 0	Positions of Stars very near the South Pole, from Observations at the Cape of Good Hope since 1829
473	Newcomb, S	1866	57	Circumpolar Stars	Declinations	1860 0	"On the Lat and Long of the U S Naval Observatory, Washington, and the Declinations of certain Circumpolar Stars" In 'Washington Observations, 1864,' App
474	Santiago Catalogue (Moesta, C G)	1875	3,309	To 9 Mag	R A , N P D	1860 0	"Observaciones Astronomicas hechas en el Observatorio Nacional de Santiago de Chile en los años de 1856 a 1860, Dresde, 1875"
475	Hall, Asaph		151	*Præsepe* to 11 Mag	R A , Decl	1860 0	"Catalogue of 151 Stars in *Præsepe*" In "Washington Observations, 1870" App IV
476	Johnson, M J	1858	1,481	To 9 Mag	R A , N P D	1860 0	"A Provisional Catalogue of 1,481 Stars, deduced from the Observations at the Radcliffe Observatory during the years 1854–56 ' In "Radcliffe Observations, 1856"
477	Secchi, A	1860	1 321	Double Stars	R A , Decl	1860 0	' Catalogo di 1,321 Stelle Dopie misurate col grande Equatoriale di Merz all' Osservatorio del Collegio Romano, Roma, 1860" Stars from Struve, in five orders of distances 0″ to 1″, 1″ to 2″, 2″ to 4″ 4″ to 8″, 8″ to 12″
478	Wrottesley, Lord	1861	398	Double Stars	R A , N P D	1860 0	' A Catalogue of the Positions and Distances of 398 Double Stars ' In "Ast Soc Roy Mems," vol xxix
479	Pogson, N	1856	53	Variable Stars	R A , N P D	1860 0	"Catalogue of 53 known Variable Stars, with Notes" In ' Radcliffe Observations, 1854, Oxford, 1856"
480	Dien, Ch		100,000	Stars and Nebulæ		1860 0	"Atlas Céleste, contenant plus de 100,000 Étoiles et Nébuleuses, d'après les Catalogues les plus exacts des Astronomes Français et Étrangers 26 Maps

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
						A D	
481	Brothers, A	1867	155 42	Binary Stars Doubtful Binary Stars	R A , Decl	1860 0	"Catalogue of Binary Stars" In "Manchester Lit Phil Soc , 1867" Gives measures of distance and position angle by several observers
482	Greenwich New 7-year Catalogue (Airy, G B , Ast Roy)		2,760	To 9 Mag	R A , N P D	1864 0	"New Seven-year Catalogue of 2,760 Stars deduced from Observations extending from 1861 to 1867, at the Royal Observatory, Greenwich" In "Greenwich Observations, 1868," Appendix
483	Schjellerup, H C F C	1864	10,000	To 10 Mag	R A , Decl +15° to −15°	1865 0	"Stjernefortegnelse indeholdende 10,000 Positioner af Teleskopiske Fixstjerner imellem −15 og +15 Gradus Deklination, Kjøbenhavn, 1864" Made with the Copenhagen meridian circle in the years 1861–63
484	Gyldén, H	1868	43	Fund Stars	Declinations	1865 0	"Vorlaufige Vergleichung der Declinationen des Poulkowaer Verticalkreises mit einigen anderen Verzeichnissen"
485	Schultz H	1873	104	Small Stars	R A , Decl	1865 0	"Mikrometrisk Bestamning af 104 Stjernor inom Telescopiska Stjerngruppen 20 Vulpeculæ" Stars in the Cluster 20 H VIII In "Stockholm Kongl Vet Akad ," vol xi , 1873
486	Pihl, O A L	1869	85	Small Stars	R A , Decl	1865 0	"Micrometric Examination of Stellar Cluster in *Perseus*, Christiania, 1869" A Catalogue of Stars in the Cluster 34 *Messier* Also in "Ast Soc Roy Mon Nots ," vol xxviii
487	Schultz, H	1875	440	To 9 Mag	R A , Decl	1865 0	"Om Komparations Stjernorna vid Nebulosobservationerna i Upsala" From meridian observations at Upsala In "Stockholm Akad K Svenska, Vet Bihang Handlingen," Band 2, No 16
488	Vogel, H C	1867	110	Comparison Stars	R A , Decl	1865 0	"Beobachtungen von Nebelflecken und Sternhaufen, Leipzig, 1867" Comparison stars used in determining the places of nebulæ
489	Schonfeld	1862	254	To 9 Mag	R A , Decl	1865 0	"Astronomische Beobachtungen auf der Grossherzoglicher Sternwarte zu Mannheim, Mannheim, 1862" Comparison stars from Bonn observations for determining the places of nebulæ
490	Arrest, H L D'	1864	212	To 16 Mag	R A $0^h\ 14^m\ 46^s$ to $0^h\ 19^m\ 7^s$ Decl +63° 9′ to +64°	1865 0	"Resultater af en Teleskopisk Undersøgelser af egnen omkring det Sted paa Himmelen hvor Tycho's nye Stjerne har viist sigi Aarene 1572–1574" A telescopic examination of the region of the heavens in which Tycho's new star appeared in 1572, adopting the position assigned by Hind, viz R A $0^h\ 17^m\ 7^s$, Decl +63° 23′ 5″, as a centre In "Copenhagen Danske Vid Selsk Oversigt 1864," p 6
491	Respighi, L	1868	88	Prin Stars	Declinations	1866 0	"Sulla Latitudine dell' Osservatorio della Romana Univ sul Campidoglio" In "Roma Accad Pont Nuovi Lincei Atti," vol xxi p 41

492	Engelmann, R	1870	146	Prin Stars	R A , Decl	1866 0	"Resultate aus Beobachtungen auf der Leipziger Sternwarte Leipzig, 1870"
493	First Melbourne General Catalogue (Ellery, R L J)	1874	1,227	To 9 Mag	R A , Decl	1870 0	"First Melbourne General Catalogue of 1,227 Stars for the Epoch 1870, deduced from Observations extending from 1863 to 1870, made at the Melbourne Observatory, Melbourne, 1874"
494	White, E J	1873	56	Near South Pole	R A , N P D	1870 0	Catalogue of Stars near the South Pole, prepared for the use of the Transit of *Venus* Expedition, from Observations with the Melbourne Transit Circle In "Ast Nach ," No 1946
495	Valentiner, W	1873	57	Fund Stars	Declinations	1870 0	From observations with the Leyden meridian circle, 1864 to 1868 In "Ast Nach ," No 1902
496	Newcomb, S		169	Fund Stars	R A N P D	1870 0	"Mean Positions for 1870 0 of Stars of the American Ephemeris, deduced from Observations with the Transit Instrument and the Transit Circle during the years 1862–67 ' ' Washington Observations, 1867," Appendix iii p 41
497	Barclay, J G	1870	217	Double Stars	R A , N P D	1870 0	"Astronomical Observations taken during the years 1865–69 at Leyton, Essex, London, 1870," vol ii
498	Barclay J G	1873	91	Double Stars	R A , N P D	1870 0	"Astronomical Observations taken during the years 1865–69 at Leyton, Essex, London, 1870," part 3
499	Chambers, G F	1867	121	Variable Stars	R A , Decl	1870 0	"Catalogue of Variable Stars" In "Descriptive Astronomy, Oxford, 1867," p 577
500	Chambers, G F.	1865	113	Variable Stars	R A , Decl	1870 0	In "Ast Soc Roy Mon Nots ," vol xxv
501	Chambers, G F	1867	293	Red Stars	R A , Decl	1870 0	In "Descriptive Astronomy, Oxford, 1867," p 584
502	Secchi, A	1876	444	Red and Colored Stars	R A , Decl	1870 0	Prodromo di un Catalogo fisico delle Stelle Colorate" In "Spettri Ital Soc Mem ," vol v
503	Winlock, J	1873	156	Fund Stars	Right Ascen 12^h to 24^h	1871 0	' Results in R A of Observations of 156 Fund Stars, observed at Harvard College Observatory" In "Ast Nach ," No 1909
504	Winlock, J	1873	27	Fund Stars.	Right Ascen N of 60° Decl	1871 0	In "Ast Nach ," No 1909
505	Winlock J	1873	121	Fund Stars	R A , Decl S of +60°	1871 0	Stars from the Fundamental List of the Astron Gesell In 'Ast Nach ,' No 1947
506	Winlock J		45	Fund Stars	R A , Decl N of +60°	1871 0	Stars from the Fundamental List of the Astron Gesell In Ast Nach ,' No 1947
507	Fergola, E	1873	106	Prin Stars	R A , Decl	1871 0	"Determinazioni novella della Latitudine dell' Osservatorio di Capodimonti" 53 Pairs of Stars, distant in Declination, close in Right Ascension In "Naples Accad R Atti, vol v , 1873, No 23

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch.	Notes
						A D	
508	Stone, E J	1873	78	Near South Pole	R A , N.P D	1871 0	From Observations made at the Royal Observatory, Cape of Good Hope In "Ast Soc Roy Mon Nots," vol xxxiii p 55.
509	Tacchini		1,001	To 9 Mag	R A , Decl −18° to −28°	unreduced	"Osservazioni di Stelle Australi esequite al Cerchio Meridiano del R Osservatorio di Palermo" In "Palermo Ist Tecnico Giornale," vols iii iv v
510	Gottingen Catalogue (Copeland, R, and Borgen, C)	1869	6,595	To 9 Mag	R A , Decl − 0° to − 1°	1875 0	"Mittlere Oerter der in den Zonen −0° und −1° der Bonner Durchmusterung enhaltener Sterne bis zu 9m 0 Grosse beobachtet und auf 1875 0 reducirt" Gottingen, 1869
511	Poulkova Catalogue (Struve, O)	1868	536	Fund Stars	R A , Decl in Zones of 10° from −10° to +90°	1875 0	Catalogue of Fundamental Stars for the new Zone Observations of the Northern Heavens to Stars of the 9 Mag In 'Ast Gesell Viertel, 1868," p 169
512	Poulkova Catalogue (Struve, O)	1869	539	Fund Stars	R A , Decl	1875 0	Catalogue of Fund Stars arranged in order of R A In "Ast Gesell Viertel, 1869," p 324
513	Gylden, H	1874	103	Fund Stars	R A	1875 0	In "Stockholm Kongl Akad Vetens Ofversigt Forh 1874" No 10 Also in "Ast Soc Roy Mon Nots," vol xxxv p 349
514	Pritchard, C	1874	12	Close Circumpolar Stars	R A , Decl	1875 0	"Ephemeris of 12 close Circumpolar Stars, suitable for the determination of Azimuth Error" Places derived from the Red Hill Catalogue and the Radcliffe Observations In 'Ast Soc Roy Mon Nots," vol xxxv p 115
515	Dollen, W	1874	240	Time Stars	R A , Decl	1875 0	In "Die Zeitbestimmung vermittelst des tragbaren Durchganginstruments," vol ii
516	Argelander, F W A	1869	160	Prin Stars	R.A , Decl	1875 0	"Mittlere Positionen von 160 Sternen abgeleitet aus altern und neuern Beobachtungen" In 'Astronomische Beobachtungen auf der Sternwarte zu Bonn," vol vii Bonn, 1869
517	Safford, T H	1873	801	B A C Stars	R A XII hours to II hours, Decl −30° to −60°	1875 0	Catalogue of the Mean Declinations of 981 Stars between Twelve Hours and Twenty-six Hours of Right Ascension, and Thirty Degrees and Sixty Degrees of North Declination, Washington 1873 The R A s are considered but approximate The Declinations were prepared for Latitude Observations by the Engineers engaged on the U S Lake Survey
518	Safford, T H	1873	180	Not in B A C	R A XII hours to II hours; Decl −30° to +60°	1875 0	

519	Struve, F G W. (Lindsay, Lord)	1876	2775	Double Stars	R A , Decl	1875 0	"A Summary or Index of the Measurements in the 'Stellarum Duplicium et Multiplicium Mensuræ Micrometricæ, F G W Struve, 1837', 'Additamentum in F G W Struve "Mensuras Micrometricas Stellarum Duplicium, editas anno 1837, Petrop 1840"' Including all the Stars in the 'Synopsis Observationum de Stellis Duplicibus in Specula Dorpatensi annis a 1814 ad 1824, per instrumenta minora perfectorum,' p 305, and in the 'II Mensuræ Micrometricæ,' p 315 Re-arranged in order of R A and positions brought up to 1875" Dun Echt Observatory Publications, vol 1 Dun Echt, Aberdeen, 1876
520	Dorna, A		634	Prin. Stars	R A Decl	1880 0	"Catalogo delle 634 Stelle Principali visibili alla Latitudine media di 45°" In "Turin Acad Mems," 2nd Series, vol xxvi
521	Herschel, J F W	1867	812	Double Stars	R A , N P D	1880 0	"A Synopsis of all Sir Wm Herschel's Micrometrical Measurements" In 'Ast Soc Roy Mems," vol xxxv
522	Wilson, J M, and Seabroke, G. M	1875	447	Double Stars	R A , Decl	1880 0	"Catalogue of Micrometrical Measurements of Double Stars made at the Temple Observatory" In "Ast Soc Roy Mems," vol xlii
523	Gledhill, J ..	1875	484	Double Stars	R A , Decl.	1880 0	"Measures of 484 Double Stars made at Mr Edward Crossley's Observatory" In "Ast Soc Roy Mems," vol xlii
524	U S Coast Survey (Peirce)	1875	2,164	To 5 9 Mag	Approx R A , Approx Decl — 1° 48′ to + 88° 40′	1880 0	"A List of Stars for Observations of Latitude" Contains all stars to the 5 9 Mag, inclusive, that are found in Argelander's Durchmusterung between 88° 40′ North and 1° 48′ South declination The magnitudes reduced to a scale of "equable distribution," according to Peirce's method in Harvard Coll Obs Annals In "U S Coast Survey Report 1873, Washington, 1875," p 139
525	Cincinnati Catalogue (Howe)	1876	50	Double Stars	R.A., Decl	1880 0	"Catalogue of 50 New Double Stars, discovered with the 11-inch Refractor of the Cincinnati Observatory" Gives measures of position and distance Publications of the Cincinnati Observatory, No 1 Cincinnati, 1876
526	Mitchel, O M (Stone, O) .	1876	176	Double and Triple Stars	R A., N P D	1880 0	"Micrometrical Measures of 176 Double and Triple Stars, observed with the 11-inch Refractor of the Cincinnati Observatory, by O M Mitchel" From observations in the years 1846–1848 Publications of the Cincinnati Observatory, No 2 Cincinnati, 1876
527	Proctor, R A	1866	1500	To 5 Mag	R A , Decl Approx	1880 0	"Handbook of the Stars," London 1866, p 47 Stars are arranged according to constellations

Catalogues of Proper Motions

No	Name	Date Published	Number of Stars	Description of Stars	Co ordinates	Notes
1	Mayer, Tobias	1775	80	Prin Stars	Proper Motions in R A and Decl	In " Opera Inedita," vol 1 p 80 Gottingæ, 1775
2	Lalande, J		20	Prin Stars	Proper Motion in Decl	In " Conn des Temps, 1796 '
3	Triesnecker, F de Paula	1791	67	Prin Stars	Proper Motions in R A and Decl	De motibus propriis Fixarum in Ascensionem rectam et Declinationem Disquisitio Hell's " Vienna Ephemeris, 1792," p 380
4	Hell, M ...	1791	17	Prin Stars	Latitudes	Catalogus quarundum Fixarum latitudinis variabiles habentium " Vienna Ephemeris, 1792," p 392
5	Zach, De	1792	92	Prin Stars	Proper Motion in R A	In " Fixarum Præcipuarum Catalogus Novus Gothæ, 1792 " Proper Motions according to Maskelyne, T Mayer and Triesnecker
6	Zach, De	1792	81	Prin Stars	Proper Motion in Decl	In "Fixarum Præcipuarum Catalogus Novus Gothæ, 1792 " Proper Motions according to T Mayer and Triesnecker
7	Piazzi, G	1806	309	Prin Stars	Proper Motions in R A and Decl	" Saggio sui Movimenti Proprii delle Fisse " In " Bologna Ist Nat Ital Mem Fis e Mat ," vol 1 pt 1
8	Lalande J		516	Prin Stars.	Proper Motion	In " Conn des Temps, 1808 "
9	Pond, J , Ast Roy		45	Prin Stars	Proper Motion	" Catalogue of the Proper Motions of 45 Stars, with the amount from 1756 to 1813 " In " Greenwich Observations, 1820–22 "
10	Baily, F	1833	314	Prin Stars	Proper Motions in R A and Decl	' On the Proper Motion of the Fixed Stars " In " Ast Soc Roy Mems ," vol v
11	Argelander, F G A	1835	560	To 8 Mag	Proper Motions in R A and Decl.	" DLX Stellarum Fixarum Positiones Mediæ ex observationibus Aboæ habitis deduxit " Helsingfors, 1835.
12	Taylor, T G	1844	732		Proper Motions in R A and Decl	" Proper Motion of the Fixed Stars " In " Appendix to the Madras Gen Cat of 11,015 Stars "
13	Galloway	1847	81	Prin Stars	Proper Motions in R A and Decl	On the Proper Motion of the Solar System " Phil Trans , 1847," p 106
14	Main, R	1851	877	Prin Stars	Proper Motions in R A and N P D	' Proper Motions of the Stars contained in the Greenwich 12 year Catalogue of 2,156 Stars deduced by comparison with the results of Bradley s Observations as given in the ' Fund Ast ' for the Epoch 1755," Part 1 Stars in the Gr Cat of 1,439 Stars In " Ast Soc Roy Mems ," vol xix
15	Main, R	1851	293	Prin Stars	Proper Motions in R A and N P D	Part 2 Stars in Gr 12-year Cat not included in the Cat of 1,439 Stars In " Ast Soc Roy Mems ," vol xix

16	British Association Catalogue (Baily)	1845	8,377	To 8 Mag	Proper Motions in R A and N P D	Gives Proper Motions for most of the stars, specially determined for this Catalogue
17	Struve, F G W	1852	384	Prin Stars	Proper Motions in R A and Decl	"Catalogue of the Proper Motions of 384 of Bradley's Stars" In "Stell Fix Imp Dup et Mult Pos Med ,' p clin
18	Oeltzen, W	1855	1,696		Proper Motions in R A and Decl	The Proper Motions of 1,696 Stars deduced from a comparison of Lalande's "Histoire Céleste," reduced to 1842 0 and Argelander's Northern Zones In "Vienna Acad K K Sitzungsber," vol xvi p 540
19	Madler, J H	1856	3,222	Bradley's Stars	Proper Motions in R A and Decl	"Die Eigenbewegungen der Fixsterne in ihrer Beziehung zum Gesammtsystem von J H Madler," Dorpat, 1856 "Dorpat Observations, vol xiv p 14
20	Robinson, T R	1859	1,783	To 8 Mag	Proper Motions in R A and N P D	Armagh Catalogue of 5,345 Stars, p xxxiv
21	Main, R	1860	270	Prin Stars	Proper Motions in R A and N P D	"Proper Motions of Stars of the Gr Cat of 1,576 Stars for 1850 not included in the Gr 12-year Cat" In "Ast Soc Roy Mems ," vol xxviii
22	Airy, G B , Ast Roy	1860	113	Prin Stars	Proper Motions in R A and N P D	"On the Movement of the Solar System in Space" In "Ast Soc Roy Mems ," vol xxviii
23	Laugier, E ..	1860	140	Fund Stars	Proper Motions in N P D	'Determination des Distances Polaires et des Mouvements propres de 140 Étoiles Fondamentales" "Comptes Rendus," vol xliv , and "Acad des Sciences Mêms," vol xxvii pt 2
24	Quetelet, Er	1861	343	Prin Stars	Proper Motion in R A	"Essai sur le Mouvement Propre en Ascension Droite de quelques Étoiles" In "Belgium Acad R Mems ," vol xxxii
25	Gould, B A ..	1862	48	Circumpolar	Proper Motions in R A and Decl	' On the Mean Places for 1855 0 of 48 Circumpolar Stars ' "Gould's Ast Journ ,' vol vi p 78
26	Dunkin, E	1864	1,167	Prin Stars	Proper Motions in R A and N P D	"On the Movement of the Solar System in Space, deduced from the Proper Motions of 1,167 Stars" In "Ast Soc Roy Mems , ' vol xxxii
27	Stone, E J .	1865	460	..	Proper Motions in R A and N P D	"Proper Motions of the Stars in the Greenwich Seven-year Catalogue of 2,022 Stars for 1860, not included in the Greenwich Twelve-year and Six-year Catalogues" In "Ast Soc Roy Mems ," vol xxxiii
28	Argelander, F W A	1869	250	To 8 Mag	Proper Motions in R A and Decl	Catalogue of the Proper Motions of 250 Stars "Untersuchungen uber die Eigenbewegungen von 250 Sternen nach altern und den auf der Bonner Sternwarte angestellten Beobachtungen ' In ' Bonn Ast Beob ," vol vii
29	Stone, E J	1875	406	Southern Stars	Proper Motions in R A and N P D	"Proper Motions of 406 Southern Stars deduced from a comparison of the places of the Cape Catalogue of 1,159 Stars for 1860 with those of certain earlier Catalogues" In "Ast Soc Roy Mems ," vol xlii

ABOUL HHASSAN'S *Table of the Longitudes and Latitudes of* 240 *Stars,*

For the Commencement of the Hegira (Thursday, July 15, *Noon,* A D 622) (Sédillot)

No	Name after the Arabian Author	Mag	Long			Lat		Bayer's Letter, or Flamsteed's No	Notes
			s	°	′	°	′		
1	La Mediale des Autruches, ou le Ventre de la Baleine	3 *p*	0	1	38	−20	00	ζ Ceti	The Longitudes are those of the "Almagest," increased for 105 stars by 6° 40′, for 102 stars by 6° 38′, and the remaining Longitudes differ from Ptolemy by 6° 36′, 6° 37, 6° 39′ and 6° 42′ The Latitudes are identical with Ptolemy's, all the stars without exception being in his Catalogue I have marked North and South Latitude by plus and minus signs, and have designated the Signs of the Zodiac numerically In the Magnitudes, "*g*" means *grand*, and "*p* *petit*, so that 3 *g* corresponds to Argelander's 3–2 and "3 *p*" would mean 3–4
2	Celle qui est entre les épaules d'Andromede	2 *p*	0	1	13	+24	30	δ Andromedæ	2 Longitude Ptolemy + 6° 38′ = 1° 58′ The number 13′ in Sedillot is most probably erroneously translated for 58 the Arabic characters for the two numbers differing only by a few dots ىح = 13 ىح = 58
3	Alzhalime, qui est la dernière du Fleuve	1	0	6	47	−13	20	θ Eridani	3 This star is designated by Schjellerup in "Al-Sûfi," as α *Eridani*, but Baily, in his edition of Ptolemy's Catalogue, gives it as θ *Eridani* (see his note to Star 805, Ptolemy's Catalogue) Ptolemy, Al Sûfi, Chrysococca, Aboul Hhassan, Ulugh Beigh, and Al-Tizini, all designate this star as "1st magnitude," though no such bright star is to be found in the portion of the heavens indicated. Baily's suggestion that the magnitude has changed is very improbable He says that the 1st magnitude star *Achernar*—the real "Ultima Fluvii"—was not visible at the latitude of Alexandria
4	Le Nœud des Deux-fils (des Poissons)	3 *p*	0	9	8	− 8	30	α Piscium	
5	Le Ventre du Grand Poisson, qui est pres d'Andromede		0	10	29	+26	20	β Andromedæ	
6	L'Australe des Cherathaine	3	0	13	18	+ 7	20	γ Arietis	
7	La Boréale des Chérathaine		0	14	15	+ 8	20	β Arietis	
8	La Main-teinte ou Bosse du Chameau	3	0	14	28	+51	40	β Cassiopeiæ	
9	L'Œil de la Baleine	4	0	16	50	− 8	10	ν Ceti	
10	La Barbe ou Mandibule de la Baleine (sur le Menton)	3 *p*	0	17	9	−14	00	δ Ceti	
11	Al-Nâthihh, cornupeta (la Brillante de la Mouche)	3	0	17	18	+10	00	α Arietis	
12	La Poitrine de Cassiopée	3	0	17	28	+46	45	α Cassiopeiæ	
13	Le Sommet du Triangle	3	0	17	38	+16	30	α Trianguli	
14	La Bouche de la Baleine	3	0	19	18	−11	30	γ Ceti	
15	La Boreale des Anisaine, ou la Boréale de la Base du Triangle	2	0	22	38	+20	40	β Trianguli	
16	La Cuisse du Cassiopée	3	0	23	18	+49	00	γ Cassiopeiæ.	
17	Anâkhal-ardhe, ou le Pied d'Andromède	3	0	23	28	+28	10	γ Andromedæ	
18	L'Australe des Anisaine, ou l'Australe de la Base du Triangle	3	0	23	28	+19	00	γ Trianguli	
19	La Main tronquée (elle est de la Barbe ou Machoire inférieure de la Baleine)	3	0	24	18	−12	20	α Ceti	

20	L'Australe d'Albothaine	5	0	26	19	+ 1	10	ρ Arietis
21	(Wanting)	3	0	27	2	+45	30	δ Cassiopeiæ
22	(Wanting) ••	5	0	28	00	+ 4	50	ε Arietis
23	La Médiale d'Albothaine	4	1	00	30	+ 1	40	δ Arietis
24	L'Australe de la Section du Taureau	4 *g*	1	00	58	− 9	15	ο Tauri
25	(Wanting)	4	1	1	18	− 8	30	ξ Tauri
26	La Boreale, ou Milieu de la Section	5	1	2	38	− 7	15	S Tauri
27	Maethame-al-Tsuriach, le poignet des Pleiades	3	1	3	18	+40	30	Cluster χ Persei
28	La Tete de Meduse, ou Al-Rhôl		1	6	18	+23	00	β Persei
29	La Première des Pleiades (c'est la Boréale du coté d'Al-Rhôl)	5	1	8	48	+ 4	30	Fl 19 Tauri
30	L'Épaule de Persee	3	1	9	18	+35	30	γ Persei
31	La Poitrine du Taureau	3	1	10	18	− 8	00	λ Tauri
32	L Exterieure au Nord des Pleiades	4	1	10	18	+ 5	00	Fl 18 Tauri
33	La Boreale du Haut de l Épaule des Pleiades (c est celle qui est en avant)	3	1	10	45	+12	00	ο Persei
34	Le Côté de Persée	2	1	11	28	+30	00	α Persei,
35	L'Australe du Haut de l'Épaule des Pleiades (c'est la Derniere)		1	12	58	+11	10	ζ Persei
36	Le Genou de Persée	3	1	15	17	+19	15	ε Persei
37	L Angle du Lam grec (le Lambda)	3	1	15	38	− 5	45	γ Tauri
38	L Œil Boreale du Taureau	1	1	18	28	− 8	00	ε Tauri
39	Aldebaran, ou le Hhadie, le Conducteur	3	1	19	18	− 5	10	α Tauri
40	La Sixième de Al-Taje la Couronne Royale	3	1	21	27	−15	50	π^1 Orionis
41	La Cheville du Pied Gauche du Cocher	1	1	26	28	+10	10	ι Aurigæ
42	Le Pied d Orion (Rigel) ••	4	1	26	30	−31	30	β Orionis
43	Al-Anze la Chevre	2	1	28	37	+20	40	ε Aurigæ
44	L Épaule Gauche d'Al-Jouza (d Orion)	3	2	00	38	−17	30	γ Orionis
45	Le Ventre du Lievre		2	1	28	−44	20	β Leporis
46	Al-Aioukhe (la Brillante de la Chèvre)		2	1	37	+22	30	α Aurigæ
47	La Premiere de la Ceinture d'Orion		2	2	00	−24	10	δ Orionis
48	La Corne attachee (boreale) du Taureau Cornu alligatum		2	2	20	+ 5	00	β Tauri

The latitude of this star in Ptolemy = −53° 30′, in Chrysococca (quoting Persian tables) and Aboul Hhassan it is given erroneously as −13° 20′ This error of 40° occurring in Arabic and Persian tables differing 120 years in date is curious It does not appear to exist in any edition of the "Almagest," but it is explicable through mistranslation or confounding of the Arabic characters*

يج = 13 نج = 53

7 Longitude of Ptolemy +6° 38′ = 14° 18′ The difference of 15′ for 18′ is difficult to explain, the Arabic characters for these numbers being quite dissimilar

9 Schjellerup, in Al-Sûfi, gives this star as ξ^2 *Ceti*, but ν *Ceti*, as suggested by Baily, is the only bright star in the "Eye of the Whale"

17 Latitude in Ptolemy = +28° 00′

21 Longitude differs 6° 42 from Ptolemy

28 It is singular the magnitude of *Algol* should be omitted by Aboul Hhassan, and it suggests his knowledge of its variability

30 Latitude Ptolemy = +34° 30′ The discrepancy of 35° for 34° is probably due to confounding the characters in the original Arabic

لد = 34 له = 35

33 Longitude Ptolemy +6° 38′ = 10° 48′ The difference of 45 for 48′ is not easily explained Aboul Hhassan s longitudes of this star and No 7 differ from Ptolemy by +6° 35

35 Latitude Ptolemy = +11° 00

38 Latitude Ptolemy = −3° 00′ This discrepancy of 8° for 3° in Aboul Hhassan is clearly due to Arabic mistranslation

ج = 3 ح = 8

The magnitudes of 38 and 39 have been interchanged

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* It is strange that Delambre, in giving Chrysococca's Catalogue, should not have noticed this error

No	Name after the Arabian Author	Mag	Long			Lat		Bayer's Letter, or Flamsteed's No
			s	°	′	°	′	
49	Le Corps du Lièvre		2	2	30			α Leporis
50	L'Antérieure d'Anourai Al-Arheribah, ou les Deux Brillantes des Corbeaux.							444 Lacaille
51	Al-Hakheah, ou la Tête d'Orion		2	3	40	−13	50	λ Orionis
52	La Seconde de la Ceinture (d'Orion)		2	4	00	−24	50	ε Orionis
53	La Corne Australe du Taureau	3	2	4	18	− 2	30	ζ Tauri
54	La Troisième de la Ceinture (d'Orion)		2	4	49	−25	40	ζ Orionis
55	Le Genou (d'Orion)	3 *g*	2	6	50	−33	30	κ Orionis
56	Al-Judie (la Brillante de la Queue de la Petite Ourse)	3	2	6	50	+66	00	α Ursæ Min
57	L'Epaule d'Orion (la Droite)	1	2	8	40	−17	00	α Orionis
58	L'Epaule Droite du Cocher	2	2	9	28	+20	00	β Aurigæ
59	Le Poignet Droit du Cocher	3	2	9	30	+13	20	θ Aurigæ
60	La Première d'Al-Haneah (c'est la boréale)	4 *g*	2	13	10	− 1	30	η Geminorum
61	La Seconde d'Al-Haneah	4	2	14	50	− 1	5	μ Geminorum
62	Le Pied du Chien	3	2	16	18	−13	45	ζ Can Maj
63	La Troisieme d'Al-Haneah	3 *p*	2	16	19	− 3	30	ν Geminorum
64	Merzame Al-Abour	4	2	17	40	−41	20	β Can Maj
65	La Quatrieme d'Al-Haneah	3	2	18	40	− 7	30	γ Geminorum
66	Le Genou du Premier des Gemeaux	3 *p*	2	19	40	+ 1	30	ε Geminorum
67	La Cinquième d'Al Haneah	4	2	21	20	−10	30	ξ Geminorum
68	Soheil al Iemen (Canope)	1	2	23	50	−75	00	α Argûs
69	Chiera-al-Abour (Sirius transiens)	1	2	21	18	−59	10	α Can Maj
70	Al Sukkane, l'Ancre Boréale	3	2	26	50	−65	40	557 Lacaille
71	Le Gemeau Boreal, ou le Bras Anterieur (c est le boreal)	3	2	29	58	+ 9	40	α Geminorum
72	La Boreale des Adzara Vierges ..	3	3	00	20	−51	30	ε Can Maj
73	La Boreale des Adzara, des Vierges	3	3	1	20	−46	10	o^2 Can Maj
74	Chiera Al-Rhomeisha	4	3	1	38	−14	00	β Can Min
75	Le Bras Étendu	4	3	3	20	+ 6	15	β Geminorum

Notes—continued

40 This star is given by Schjellerup in Al-Sûfi as π^3 *Orionis* According to the maps of the S D U K the position agrees best with π^1 *Orionis* as given by Baily

41, 42 The magnitudes of these stars have been interchanged

50 444 Lacaille is the only star, of those designated by Al-Sûfi as forming *Al-Arheribah* or *Al-Agribat* which has a longitude suitable to the position given by Hhassan to No 50 in his Catalogue Longitude Ptolemy (Liechtenstein) $+6^\circ 40' = 2^s 3^\circ 40'$

51 The latitude agrees with Al-Sûfi, but differs from all editions of the "Almagest" See Baily's note to Star 734 Ptolemy's Catalogue, in which he says "there is probably a mistake in all the copies"

60, 61, 63, 65, 67 Al Sufi and Ulugh Beigh restrict the name *Al-Haneah* to the two stars 65 and 67 Al-Tizini (Hyde's "Commentary on Ulugh Beigh," p 79) includes five stars in *Al-Haneah* Ideler derives the name from the verb "to bend," and Sprenger gives the meaning as "curved" The five stars η, μ, ν, γ and ξ *Geminorum* certainly form a curved line, and it would therefore seem probable that the Arabs Hhassan and Al-Tizini have applied the name *Al-Haneah* more correctly than the Persians Al-Sufi and Ulugh Beigh Schjellerup says* that Kazimirski's signification of the word, "Name of 5 stars disposed in a series in the left arm of *Orion*," is evidently false But if we read "*near* the left arm of *Orion*," it would be correct

61 Latitude Ptolemy = $-1^\circ 15'$

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* Schjellerup's "Al-Sûfi," note

76	La Médiale des Adzara, des Vierges	3	3	3	20	−48	45	δ Can Maj
77	Celle qui suit Soheil (Canope)	3 *p*	3	5	36	−71	45	579 Lacaille
78	Al-Rhomeisha	1	3	5	50	−16	10	α Can Min
79	La Restante des Adzara, ou Queue du Chien	3	3	8	50	−50	40	η Can Mag
80	Ters-Al-Sefinah, le Bouclier du Navire	4 *g*	3	13	00	−47	15	κ Argûs
81	La Troisième du Navire	4 *g*	3	15	28	−45	00	ξ Argûs
82	Al-Natsrah, dite Al-Maalef, l'Etable		3	17	00	+00	40	ε Cancri (Præsepe)
83	L'Externe de la Tete de l'Hydre, vers le Midi	3	3	19	8	−23	15	30 Monocerotis
84	La Queue du Dragon	3 *p*	3	19	50	+56	55	λ Draconis
85	La Deuxième du Navire	3	3	20	18	−43	20	ι Argûs
86	La Bouche de l'Hydre	4	3	20	8	−14	15	η Hydræ
87	La plus Brillante des Deux-Veaux, Ferkhadaine		3	23	50	+72	50	β Ursæ Min
88	La Premiere d'Al-Naeche, ou le Dos de la (Grande) Ourse		3	24	20	+49	00	α Ursæ Maj
89	La Machoire inférieure ou la Barbe de l'Hydre	4 *g*	3	24	28	−12	00	ζ Hydræ
90	Le Tapis (ou peut-être le Pont) du Navire		3	27	50	−18	20	δ Argûs
91	La Boreale d'Al-Tharf	4	3	27	50	+ 7	30	λ Leonis
92	L'Australe d Al-Tharf	4	3	28	20	− 5	40	κ Cancri
93	La Boréale d'Al-Naeche, ou l'Epigastre de la (Grande) Ourse	3 *g*	3	28	50	+44	30	β Ursæ Maj
94	L'Origine du Col de l'Hydre (du côté de la Tête)	4 *p*	3	29	58	−13	40	θ Hydræ
95	L'Australe de la Tête du Lion	3	4	00	50	+ 9	30	ε Leonis
96	La Cachee d Al-Ferkhadaine	3	4	2	50	+74	50	γ Ursæ Min
97	Celle qui est sous le Tapis du Navire .	.	4	6	38	−63	50	ζ Argûs
98	Soheil, le Solitaire, ou la Vertèbre de l'Hydre		4	6	40	−20	30	α Hydræ
99	La Boreale du Front du Lion	3	4	6	48			ζ Leonis
100	L'Australe des deux Mediales du Front du Lion	3						η Leonis (?)
101	L'Épaule du Lion		4	8	50	+ 8	30	γ Leonis

62 Latitude Ptolemy = −53° 45′ The error of 13° for 53° is clearly due to mistranslation of the Arabic

يج = 13 for نج = 53

63 Longitude of Ptolemy + 6° 39 (occasionally used by Hhassan as precessional correction) = 16° 49′ It is not impossible that the discrepancy of 19′ for 49′ may be due to confounding the Arabic characters

يط = 19 for مط = 49,

but it is not so probable as that it is a clerical error

69 Longitude of Ptolemy + 6° 38′ = 24° 18′ From the fact of the stars being arranged in Hhassan's Catalogue in order of longitude, there can be no doubt that the error of 21° 18′ for 24° 18′ is due to translator or printer It is not probable that the Arabic characters for 21 and 24 have been confounded Latitude of Ptolemy = 39° 10′ Hhassan's or Sédillot's erroneous latitude of *Sirius*, 59° 10′, is most probably due to mistaking the Arabic

لط = 39 for نط = 59

85 Longitude of Ptolemy + 6° 38′ = 20° 58′ The longitude 20° 18′ given by Sédillot is probably an Arabic error of

يح = 18 for نح = 58

86 Longitude of Ptolemy + 6° 38′ = 22° 8′ From this star's place in the Catalogue, the longitude 20° 8′ is no doubt a mistake The number 20 being represented in Arabic by *one* letter, and 22 by *two*, does not suggest the source of this error

90 Latitude of Ptolemy = −58° 20′ Sédillot's latitude is a mistranslation of the Arabic

يح = 18 for نح = 58

No	Name after the Arabian Author	Mag	Long s	Long °	Long ′	Lat °	Lat ′	Bayer's Letter, or Flamsteed's No
102	Le Cœur du Lion	1	4	9	8	+00	10	α Leonis
103	Al-Jaune		4	13	50	+13	30	ε Ursæ Maj
104	La Première de la Crinière du Lion (ce sont les Rhhaïtsane)		4	20	50	+13	40	δ Leonis
105	Al-Nâchir		4	20	50	−14	30	ε Argûs
106	La Seconde de la Crinière	3	4	23	00	+ 9	40	θ Leonis
107	Al-Anâkhe		4	24	38	+55	40	ζ Ursæ Maj
108	L'Antérieure de la Ligne	3 *p*	4	24	38	−24	40	μ Hydræ
109	La Cuisse du Lion	3	4	26	58	+ 5	50	ι Leonis
110	La Dernière de la Ligne	3	4	29	38	−22	10	ν Hydræ
111	Al-Sharfah	1	5	1	8	+11	50	β Leonis
112	Le Foie du Lion	3	5	4	30	+39	45	12 Can Ven
113	Le Côte Austral d'Al-Aoua, de Bootes	3	5	5	40	+00	10	β Virginis
114	Al-Khaid, le Gouverneur	2	5	6	8	+54	00	η Ursæ Maj
115	La Médiale du Côté Austral d'Al-Aoua de Bootes	3	5	15	00	+ 1	10	η Virginis
116	La Suivante des Deux Loups	3	5	15	00	+84	50	ζ Draconis
117	L'Australe de ces Deux Loups	3	5	16	40	+78	00	η Draconis
118	Le Côte Boreal d Al-Aoua, de Bootes	3	5	18	50	+15	10	ε Virginis
119	Al-Dabahh	3	5	19	20	+70	00	ι Draconis
120	L'Angle d'Al-Aoua de Bootes	3	5	19	50	+ 2	50	γ Virginis
121	L'Aile droit du Corbeau	3	5	20	8	−14	50	γ Corvi
122	Le Col du Corbeau	3	5	21	00	−19	40	ε Corvi
123	La Mediale du Côte Boreal d'Al-Aoua, de Bootes	3	5	22	00	+ 8	30	δ Virginis
124	(La Vertebre Dorsale) du Corbeau	3 *p*	5	22	00	−21	40	α Corvi
125	(L'Aile Gauche du Corbeau)	3	5	23	17	−12	30	δ Corvi
126	L Épaule d Al-Sharahh du Crieur	3	5	26	20	+49	00	γ Bootis
127	Le Pied du Corbeau	3	5	27	7	−18	10	β Corvi

Notes—continued

97, 98 } The longitudes of these stars in Ptolemy are identical = 4ˢ 0° 00′, but Aboul Hhassan gives for the first, Ptolemy + 6° 38′, and for the latter, Ptolemy + 6° 40′ This is quite inexplicable

100 Having nothing but the description by which to identify this star we cannot be very certain of it, but probably η *Leonis* is described in which case the longitude would be 4ˢ 7° 20′ and latitude + 4° 30′

103 This star, *Al-Jaune*, is stated by Al-Sûfi to be in *Ursa Major* and the longitude is correct for ε *Ursæ Majoris*, but the latitude given, viz + 13° 30′ places it far from this constellation Ptolemy's latitude for ε *Ursæ Majoris* = + 53° 30 We have therefore in Hhassan a probable Arabic error of

يج = 13 for نج = 53

105 The longitude of this star agrees with Ptolemy (editions of Grynæus and Halma) + 6° 40′ for the 31st star in *Argo* From the declination of *Al-Nâchir* given by Hhassan in his second Catalogue, being − 39° 4′, I find the place to be that of ε *Argûs* The latitude therefore is a mistake of 14° 30′ for 54° 30′, or, in the Arabic,

يد = 14 for ند = 54

Mr Baily says, in his notes to Ptolemy s Catalogue, that two editions of Ptolemy—Liechtenstein and Trapezuntius—place this star in the *Constellation Cancer* As the latitude in the former edition is 54° 30′ and in the latter 51° 30′, with a marginal reading of 54° 30′, he must have meant the *Sign Cancer*

The name *Al-Nâchir* is not to be found in Ideler s "Untersuchungen uber den Ursprung und der Bedeutung der Sternnamen," nor the

128	L'Australe de l'Angle d'Al-Aoua	4	5	28	00	+25	00	υ Bootis
129	La Lance du Lancier	3	5	28	00	+28	00	η Bootis
130	Le Sommet du Fémur d'Adzara	3	6	1	28	+ 8	40	ζ Virginis
131	La Suivante du Triangle de l'Hydre	3	6	2	00	−31	20	28 Crateris
132	Al-Simak al-Aezal, le Delaissé	1	6	3	20	− 2	00	α Virginis
133	Al-Simak-al-Ramihh, le Lancier	1	6	3	40	+31	30	α Bootis
134	La Ceinture d'Al-Sharabh, du Crieur	3	6	6	37	+40	15	ε Bootis
135	L'Épaule Gauche du Centaure	3	6	12	48	−25	40	ι Centauri
136	L'Épaule Droite du Centaure	3	6	12	18	−22	30	θ Centauri
137	La Boréale d'Al-Rhafar, du Garde du Gardien	4	6	13	20	+ 7	30	ι Virginis
138	L'Australe d'Al-Rhafar	4	6	14	00	+ 2	40	κ Virginis,
139	L'Articulation du Pied Droit du Centaure		6	16	37	−51	10	ν Centauri
140	La Médiale d'Al-Rhafar	4	6	16	40	+ 5	30	λ Virginis
141	Le Tarse Gauche du Centaure		6	17	50	−55	20	ζ Centauri
142	La Brillante d'Al Fekah		6	21	20	+44	30	α Coronæ
143	La Cheville du Pied Droit du Centaure		6	22	00	−51	40	ξ Centauri
144	Le Plateau Austral	3 *g*	6	24	38	+00	40	α Libræ
145	Le Commencement du Corps Humain	3	6	24	38	−33	33	λ Centauri
146	L'Origine du Col du Serpent	3 *p*	6	28	40	+34	15	β Serpentis
147	Le Plateau Boréal	3 *g*	6	28	50	+ 8	50	β Libræ
148	L'Extrémité de la Queue de l'Hydre	3 *p*	6	29	18	+17	40	π Hydræ
149	Le Bras du Centaure	3	6	29	28			κ Centauri
150	Hhadhar (c'est le Hhanatse), le Parjure	*g*						γ Centauri (?)
151	Le Col du Serpent	3 *p*	7	00	18	+25	20	α Serpentis
152	La Tempe du Serpent	3 *p*	7	1	00	+36	30	γ Serpentis
153	Le Pied d'Al-Fahed, du Léopard ou du Loup	3	7	4	38	−24	50	ο Lupi
154	L'Antérieure de la Main d'Al-Fahed	4 *g*	7	4	38	−21	15	ζ Lupi
155	La Seconde de la Main d'Al-Fahed	3 *p*	7	10	18	−21	00	η Lupi
156	L'Épaule d'Agenouillé, d'Hercule	3	7	10	18	+43	00	β Herculis
157	Le Côté d'Hercule	3	7	10	28	+54	10	ζ Herculis
158	La Boréale de la Couronne	3	7	12	57	+ 1	20	β Scorpii

"Fundgruben des Orients," neither can I find it in any Oriental work. Several distinguished Arabic scholars have informed me they are quite unacquainted with the word as applied to the stars

114 Longitude of Ptolemy + 6° 38′ = 6° 28′. The discrepancy of 8′ for 28′ is not explicable through error in translation

115 Longitude differs 6° 50′ from Ptolemy

120 Schjellerup says "Sedillot is in error in supposing *Al-Aoua* (referred to here) to be in *Bootes*"

123 Longitude of Ptolemy + 6° 40′ = 21° 00′

131 The description and latitude of this star accord with Ptolemy's 23rd star in *Hydra*, but the longitude of Ptolemy + 6° 40′ = 5ˢ 22° 50′, Hhassan gives it as 6ˢ 2° 00′. This great discrepancy is very difficult to account for, but the following seems to me the most probable explanation.

The difference in longitude given by Hhassan of 6° 40′ in 484 years, between Ptolemy's epoch, A.D. 138, and the commencement of the Hejira, A.D. 622, gives an annual correction to the longitude of 49″.58. The epoch of Aboul Hhassan's 2nd and 3rd Catalogues is A.D. 1282. Reducing, therefore, Ptolemy's place to this epoch gives for the star under consideration a longitude of 6ˢ 1° 55′, or, in round numbers, 6ˢ 2° 00′, the very longitude we have in the Catalogue. Hhassan seems therefore to have unintentionally given to this star the longitude it would have at his own epoch, 1282. This differs 15° 50′ from Ptolemy, but the longitude of No. 148 differs nearly the same amount, namely, 15° 48′ from Ptolemy, or is about what it should be brought up also to 1282.

I therefore am inclined to infer that Hhassan did not take Ptolemy's Catalogue and reduce it to A.D. 622 by adding a fixed constant to the longitudes, but that the original Catalogue was for his own period, A.D. 1282, and that he reduced this back to 622—small arithmetical errors in the subtractions occasioning some of the slight variations in the amount by which the

No	Name after the Arabian Author	Mag	Long			Lat		Bayer's Letter, or Flamsteed's No
			s	°	′	°	′	
159	La Médiale de la Couronne	3	7	12	18	− 1	40	δ Scorpii
160	L'Australe de la Couronne	3	7	12	18	− 5	00	π Scorpii
161	Al-Wesne, ou le Jureur	1	7	15	00	−41	10	α Centauri
162	Al-Niiâth Al-Aouel, la Première des Entrailles	3 *p*	7	17	17	− 8	45	σ Scorpii
163	Le Genou Gauche	3	7	18	50	+51	50	ζ Ophiuchi
164	Le Cœur du Scorpion		7	19	17	− 4	00	α Scorpii
165	Al-Niiâth-Al-Tsanie, la Deuxieme des Entrailles	3	7	21	8	− 5	30	τ Scorpii
166	La Tete d'Agenouillé, d'Hercule	3 *p*	7	24	20	+37	30	α Herculis
167	Le Premier Sphondyle	3	7	25	8	−	00	ε Scorpii
168	Le Deuxieme Sphondyle	4	7	26	40	−18	40	ζ¹ Scorpii
169	Le Genou du Serpentaire	4	7	27	48	+ 7	30	η Ophiuchi
170	Le Quatrième Sphondyle	3 *p*	7	29	50	−19	30	η Scorpii
171	La Tête du Serpentaire ..	3 *g*	8	1	28	+36	00	α Ophiuchi
172	L'Australe d'Al-Chaulah	3 *p*	8	3	37	−13	30	υ Scorpii
173	La Boréale d'Al-Chaulah	3	8	4	8	−13	20	λ Scorpii
174	L'Épaule du Serpentaire	3 *p*	8	4	37	+27	15	β Ophiuchi
175	Le Cinquieme Sphondyle	3	8	4	48	−18	30	θ Scorpii
176	d'Al-Naaim Al-Waridah	3 *p*	8	11	7	− 6	20	γ Sagittarii
177	La Cheville du Pied Boréal du Sagittaire	3 *p*	8	13	20	−13	00	β Telescopii
178	Al Siah du Nord (c'est la Boreale des Zhalimaines)	4	8	13	20	+ 2	50	μ Sagittarii
179	La Poignée (de l'Arc) du Sagittaire, d'Al-Naaim Al-Waridah	3	8	14	20	− 6	30	δ Sagittarii
180	Al-Siah, du Midi, d'Al-Naaim-Al-Waridah	3 *g*	8	14	38	−10	50	ε Sagittarii
181	L'Australe d Al-Zhalimaine, ou le Pasteur	3	8	15	40	− 1	30	λ Sagittarii
182	Al-Faukhe (elle fait partie d Al-Naaim-Al Shadirah)	4	8	19	40	− 3	50	φ Sagittarii
183	L Épaule du Sagittaire (d Al-Naaim-Al-Shadirah)	3	8	22	00	− 3	10	σ Sagittarii

Notes—continued

longitudes generally differ from those of the "Almagest," and the stars 131 and 148 were unintentionally inserted without reduction

This may perhaps help to explain some of the difficulties Mr Stone experienced in examining this Catalogue *

136 Longitude of Ptolemy +6° 38′ = 22° 18′ The position of this star in the Catalogue suggests that the discrepancy of 10° in Hhassan's longitude is not due to translator It is not improbable, however, that in the original MS

كب = 22 was mistaken for يب = 12

145 Schjellerup gives this star as ζ *Centauri*, but according to Bayer's Atlas λ *Centauri* is the star described

148 Longitude of Ptolemy +6° 38′ = 20° 8′ See *ante*, note to Star 131

Latitude should be − (South)

149 In Bayer κ is the star in the arm of the Centaur, but in the maps S D U K it is designated η

150 From the longitude of this star lying presumably between 29° 28′ and 0° 58′ (see note to the following star), it should be γ *Centauri*

151 Longitude of Ptolemy +6° 38′ = 0° 58′. A probable error in translating the Arabic

نح = 58 for يح = 18

152 The latitude differs 30′ from the editions of Ptolemy

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* *Monthly Notices*, vol xxix p 102

184	La Première d'Al-Khalaishe	4	8	22	20	+ 2	10	ξ^1 Sagittarii
185	L'Aisselle du Sagittaire, d'Al Naaim-Al-Shadiiah	3	8	23	20	− 6	45	ζ Sagittarii
186	Le Genou du Sagittaire	4 *p*	8	23	37	−18	00	α Sagittarii
187	L'Aigle Tombant	1	8	24	00	+ 2	00	α Lyræ
188	L'Arrière de l'Épaule du Sagittaire, d'Al-Naaim-Al-Shadiiah	4 *g*	8	24	13	− 4	30	τ Sagittarii
189	Le Nerf du Sagittaire	4 *p*	8	24	18	−23	00	β Sagittarii
190	La Brillante d'Al-Khalaishe	4	8	25	48	+ 2	00	π Sagittarii
191	L'Australe de Zhalimai-Al-Nasr, de l'Aigle	3 *p*	8	27	50	+18	10	λ Aquilæ
192	La Queue de l'Aigle	3	8	28	50	+36	20	ζ Aquilæ
193	La Dernière d'Al-Khalaishe	4 *p*	8	29	28	+ 6	50	υ Sagittarii
194	La Troisième des Externes de la Constellation Akhab, le Grand Aigle	3 *p*	9	2	38	+25	00	δ Aquilæ
195	La Boréale d'Al-Shardaine	4 *p*	9	4	00	−13	30	θ Sagittarii
196	La Boréale d'Al-Zhalimai (Al-Nasr)	4 *p*	9	4	50	+20	00	ι Aquilæ
197	L'Épaule de l'Aigle	3	9	9	50	+31	30	γ Aquilæ
198	L'Aigle Volant	*g*	9	10	30	+29	10	α Aquilæ
199	Le Col du Grand Aigle	3 *p*	9	11	30	+27	10	β Aquilæ
200	Le Bec de la Poule, du Cygne	3 *p*	9	11	8	+49	20	β Cygni
201	L Antérieure de Saad-Al-Dzabihh, la Fortune de l'Egorgeur	3 *p*	9	14	00	7	2	α^1 Capricorni
202	La Deuxième de Saad-Al-Dzabihh	3 *p*	9	14				β Capricorni
203	La Deuxième externe du Grand Aigle	3	9	15	28	+19	10	θ Aquilæ
204	La Brillante de Saad-bela La Fortune de la Valeur	4 *g*	9	21	20	+ 8	40	ε Aquarii
205	L Anterieure du Dos du Capricorne	4	9	23	18			θ Capricorni
206	La Queue du Dauphin	4 *g*	9	24	18	+29	10	ε Delphini
207	L'Australe du Côte Antérieur, des Nœuds	4 *g*	9	25	8	+32	00	β Delphini
208	La Boréale du Côté Anterieur, des Nœuds	3 *p*	9	26	43	+33	50	α Delphini
209	Celle qui suit le Dos du Capricorne	3 *p*	9	27	38	+00	50	ι Capricorni
210	L Australe du Côté qui est apres les Nœuds	4	9	27	58	−32	00	δ Delphini

154 Longitude of Ptolemy +6° 38′ = 7° 38′ The error here of 4° for 7° is very probably due to confounding the Arabic

د = 4 and ز = 7

155 Longitude of Ptolemy +6° 38′ = 10° 48′ If this is an error in Hhassan of 18′ for 48′, it might possibly be due to badly written Arabic characters

يح = 18 for مح = 48

162 Latitude of Ptolemy = 3° 45′ Hhassan's latitude 8° 45′ is clearly due to bad writing or mistranslation of the Arabic

ح = 8 for ج = 3 *

163 From the description and longitude which equals Ptolemy's +6° 38′, this star is ζ *Ophiuchi* The latitude in Ptolemy is +11° 50′ The discrepancy in Hhassan's latitude is probably due to badly written Arabic, confounding

نا = 51 with يا = 11

167 The longitude agrees with Ptolemy for ε *Scorpii*, the latitude therefore would be −11° 00′

168 Al-Sûfi and Ulugh Beigh call this star the *third* Sphondyle

175 Latitude in Ptolemy = 18° 50′ The Arabic characters for 30 and 50 might probably be confounded

ل = 30 ن = 50

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* The Royal Astronomical Society possesses Persian MS of Ulugh Beigh's Catalogue, which contains numerous errors in the characters,

ج and ح

having been confounded by the original transcriber

No	Name after the Arabian Author	Mag	Long			Lat		Bayer's Letter, or Flamsteed's No
			s	°	′	°	′	
211	La Boréale du Côte qui est derrière les Nœuds	3 *p*	10	00	8	+ 33	10	γ Delphini
212	La Première de la Queue du Capricorne	3 *p*	10	1	30	− 2	10	γ Capricorni
213	La Brillante Saad Al-Sooud La Fortune des Fortunes	3 *p*	10	4	10	+ 8	50	β Aquarii
214	La Poitrine du Cygne, (elle est d'Al-Fouaris, les Cavaliers)	3 *g*	10	5	8	+ 56	20	γ Cygni
215	La Bouche d'Al-Fouaris, c'est (la Lèvre du Cheval) le Djaafalih	3	10	12	00	+ 22	30	ε Pegasi
216	La Brillante de Saad-Al-Mulk, la Fortune du Royaume	3 *p*	10	13	00	+ 11	00	α Aquarii
217	L'Australe d'Al-Fouaris	3	10	13	18	+ 44	00	ζ Cygni
218	La Bouche du Poisson Austral, Fomalhaut, ou la Premiere Grenouille	1	10	13	40	+ 23	00	α Piscis Austr
219	Al-Ridfe, ou la Queue de la Poule, du Cygne		10	15	48	+ 60	00	α Cygni
220	La Brillante de Saad-Al-Beham (c'est la Tête du Cheval)	3 *p*	10	16	00	+ 16	50	θ Pegasi
221	La Premiere d'Al-Arhhebiah, les Tentes	3 *p*	10	16	10	+ 8	45	γ Aquarii
222	La Seconde de la même	4 *g*	10	18	20	+ 10	45	π Aquarii
223	Saad-Al-Arhhebiah, la Fortune des Tentes	3 *p*	10	18	39	+ 9	00	ζ Aquarii
224	La Brillante de Saad-Al-Rhamam (c'est le Col du Cheval)	3 *p*	10	25	30	+ 18	00	ζ Pegasi
225	L'Australe de Saad-bari (c'est la Poitrine du Cheval)	4 *g*	11	2	48	+ 29	00	λ Pegasi
226	L'Antérieure de celle qui suit le Détour de l'Eau	4 *g*	11	3	18	+ 15	30	2 Ceti
227	La Croupe du Cheval ou l'Australe d'Al-Fazerhe Antérieur		11	3	18	+ 19	40	α Pegasi
228	ou le Genou du Cheval	3	11	5	38	+ 35	00	η Pegasi
229	L'Epaule du Cheval, ou la Boréale d'Al-Fazerhe		11	8	49	+ 31	00	β Pegasi

Notes—continued

185 Longitude of Ptolemy + 6° 40′ = 23° 00′ The difference of 20′ in Hhassan's longitude cannot be explained from any edition of the ‘Almagest ”

187 There is no doubt, from both the name and the longitude, that *α Lyræ* is here designated Latitude of Ptolemy = + 62° 00′ The error in the latitude of 2° for 62° might possibly be ascribed to badly written Arabic

ب = 2 for سب = 62

188 Longitude of Ptolemy + 6° 38′ = 24° 18′ The discrepancy of 13′ for 18′ in the longitude of this star is most probably due to misinterpretation of the Arabic

يج = 13 for يح = 18

193 Latitude of Ptolemy = + 6° 30′ The discrepancy of 50′ for 30′ is probably due to the same cause as in 175, namely,

ن = 50 for ل = 30

201 Latitude in Ptolemy = + 7° 20′ Perhaps a typographical error, though the Arabic characters,

ب = 2 and ك = 20,

might be confounded

208 Longitude of Ptolemy + 6° 38′ = 26° 48 Another probable error in the Arabic

مج = 43 and مح = 48

210 The latitude should be + (North)

230	La Boreale de la Queue de la Baleine	3*p*	11	10	58	− 9	40	ι Ceti
231	La Boréale d'Al-Kerb, du Lieu de l'Urne	4	11	11	8	+25	30	τ Pegasi
232	L'Australe d'Al-Kerb	4	11	11	38	+25	00	υ Pegasi
233	La Deuxième Grenouille (c'est la Boréale de la Queue de la Baleine)	3*g*	11	12	20	−	20	β Ceti
234	L'Aile du Cheval (Pégase) (c est l'Australe d'Al-Fazerhe Postérieur)		11	18	48	+12	30	γ Pegasi
235	La Boreale des Trois Médiales, des Autruches	3*p*	11	21	38	−15	40	η Ceti
236	L'Épaule de l'Enflammé, Céphée	3	11	23	18	+69	00	α Cephei
237	Serat-Al-Fars, ou l'Extrémité Boréale de la Tete d'Andromède		11	24	30	+26	00	α Andromedæ
238	La Boréale de l'Origine de la Queue de la Baleine (c est la Boréale des Autruches)	3*p*	11	26	20	−15	20	θ Ceti
239	L'Australe des Trois Médiales des Autruches	4*g*	11	28	40	+25	20	τ Ceti
240	L'Australe des Autruches	4	11	29	38	−30	50	υ Ceti

213 Longitude of Ptolemy +6° 40′ = 3° 10′ The discrepancy of 1° in Hhassan's longitude is not easily explained

218 The latitude should be − (South)

226 The latitude should be − (South)

233 The latitude in Ptolemy = −20° 20′

239 The latitude should be − (South)

Appendix

Note on Ulugh Beigh's Catalogue

The following discrepancies in certain MS copies of Ulugh Beigh, given by Mr Baily in his notes to that Catalogue, in volume xiii of the *Memoirs of the Royal Astronomical Society*, are, like so many errors in Aboul Hhassan's Catalogue, due probably to mistranslation of the Arabic characters —

Ulugh Beigh Baily's No of Star	°	′		°	′		Ulugh Beigh Baily's No of Star	°	′		°	′	
37	10	7	for	10	4	ر for د	316	15	15	for	15	55	يه for نه
48	21	15	„	21	55	يه „ نه	514	18	18	„	18	58	يح , نح
89	58	11	„	58	51	يا „ نا	550	2	56	„	2	16	نو „ يو
141	60	16	„	60	36	يو „ لو	643	1	15	„	1	55	يه „ نه
165	11	15	„	11	55	يه „ نه	870	60	55	„	60	15	نه „ يه
231	17	25	„	16	25	ز „ يو	945	4	15	„	4	55	يه „ نه

Appendix—cont

Note on Cardinal Cusa's Catalogue

The statement on page 15, that Cardinal Nicholas of Cusa was an original observer, and made a Catalogue of Stars from his own observations, was given on the authority of Riccioli, but it seems to require some qualification Since writing it, I have found in the British Museum a copy of his works (Khrypffs (Nich) de Cusa, *Opera*, *Basileæ*, 1565, fol) At page 1174 is given a Catalogue of the Longitudes and Latitudes of 64 Principal Stars, entitled "Catalogus Stellarum fixarum ex Cardinalium Cusani, Niceni et Alliacensis Observationibus" The latitudes are Ptolemy's, and where any difference of reading exists in the known editions of the *Almagest*, Cusa agrees with the Venice Edition of Liechtenstein, which is believed to have been translated from an Arabic MS This leads one to infer that Cusa derived the places of his stars also from the Arabic There are some errors in the Catalogue which are readily explained on the supposition of confounding the Arabic characters. For example —The latitude of *Sirius* is given as 39° 50′ instead of 39° 10′, or the very probable error of confounding the Nūn ن with the Yā ى The latitude of the northern of the *Aselli* is given as 10° 40′ for 2° 40′, or a mistake of Yā ى for Bā ب

The longitudes are those of Ptolemy increased by 21° The Epoch is not given in the above edition, but if it be A D 1440 as asserted by Riccioli, then the amount of precession adopted was 58″ annually, or one degree in sixty-two years

Ptolemy probably observed θ^1 and θ^2 *Tauri* as one star, Cusa gives both components, which appears to be the solitary observation to justify the title of his Catalogue

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Catalogues omitted

No	Name	Date Published	Number of Stars	Description of Stars	Mean Places, Co ordinates	Epoch	Notes
32A	William 4th Landgrave of Hesse	1665	24	Prin Stars	Long , Lat	1587	"Ex observatis a Lantgravio Hassiacæ et supputatione Tychonis " A Catalogue of Stars reduced by Tycho from the observations of the Landgrave of Hesse, on the assumption that the R A of *Aldebaran* for the epoch was 63° 10′ In "Riccioli, Astronomiæ Reformatæ," tom 1, p 218.
518A	*Safford, T H	1877	2018	To 7 & 8 Mag	R A 0 h to II h and XII h to XXIV h Decl +10° to +70°	1875 0	"Engineer Dept , U S Army Catalogue of the Mean Declinations of 2018 Stars between 0^h to 2^h and 12^h to 24^h R A and 10° and 70° North Decl , for Jan 1, 1875 " Washington, 1877 Catalogue was prepared for the Latitude work of the U S Engineers Includes all B A C stars within the limits mentioned In its preparation all catalogues have been consulted, including annual catalogues of Greenwich to 1874, and the Poulkova Observations in Vol vi of the "Annales"

II. *Micrometrical Measures of Double Stars.* By GEORGE KNOTT, Esq.

INTRODUCTION

I HAVE the honour of presenting to the Royal Astronomical Society a short series of micrometrical measures of Double Stars, taken between the years 1860 and 1873, at my former residence, Woodcroft, Cuckfield

The Observatory, detached, at some little distance from the house, and commanding a good horizon view, stood at an elevation above the sea level of about 370 feet, and in the approximate position, latitude 51° 0′ 41″ north, longitude $0^{h}\ 0^{m}\ 34^{s}$ west.

The Equatoreal has an object-glass of 7⅓ inches clear aperture, and 110½ inches focal length, by Messrs ALVAN CLARK & SONS, of Boston, U S.A , and is a fine specimen of the makers' skill. It was formerly in the possession of the Rev W. R. DAWES.

The filar, or parallel wire, micrometer employed in the following measures was made for me by the late Mr DOLLOND It has a position circle of 3½ inches diameter, reading, by two verniers, to tenths of a degree, and the angle of position is taken by placing the two stars under observation centrally parallel between two thick wires, about 13″ apart At right angles to the position wires are the webs for distance measures, of which two, one fine and the other coarse (the latter for measures of faint objects, but rarely used), are carried by each screw. The screwheads, divided to 100 parts, are of nearly two inches diameter, and are fitted with bolts, so that either web may be fixed as zero wire, while the other is used in making the measures There is a battery of seven eye-pieces, with magnifying powers from 115 to 515, and by the use of an achromatic concave Barlow lens, the magnifying power may be increased in the proportion of about 2 25 to 1 The micrometer is also fitted with a convenient slipping-piece The value of one revolution of the screw is 18″ 2949, and with the Barlow lens 8″ 0765

In reducing the observations, the arithmetical mean is taken as the mean for the night To each individual measure a number is assigned (1–9) expressive of its estimated worth, and the sum of these numbers is taken as the weight of the set, which is thus a function of the number of observations and of the estimated value of each measure In forming the "Mean Results" (or mean of several nights' measures), this number is introduced as the *combination weight*

Being interested in the observation of Variable Stars, I found it convenient to adopt Mr Pogson's standard scale, or Argelander's scale extended to the lower magnitudes by the adopted light-ratio 2 512 (*Monthly Notices*, vol xvii p 15) The numbers expressing the magnitudes will be found, therefore, to lie generally between those of Σ on the one hand, and of H. and Sm on the other, the difference being more marked in the lower magnitudes Although, for convenience, the magnitudes are expressed decimally, they must not be regarded as making any pretensions to very close accuracy

Cuckfield
January 11, 1877

NOTES ON STARS IN THE CATALOGUE

Abbreviations employed in the Notes.

Br	*denotes*	Brunnow	OΣ	*denotes*	Otto Struve
Da	”	Dawes	Sb.	”	Seabroke
De	”	Dembowski	Sm	”	Smyth
Gl	”	Gledhill	Σ	”	Struve.
H̥	”	Herschel I	W & S	”	Wilson & Seabroke
H	”	Herschel II	W & Sm	”	Wilson & Smith
Kn	”	Knott	P	”	Position Angle
M	”	Madler	D	”	Distance

No. 11 Σ 196 *Arietis* P. I. 222

In the Bedford Catalogue the magnitudes of A and D are interchanged, which led Professor C. Piazzi Smyth, observing with the Elchies Equatoreal (*Monthly Notices*, vol. xxiii., p. 11) to suspect variation in the group. My distance for AD is considerably larger than that given by Sm., but is confirmed by Dawes, who has (*Monthly Notices*, xxiii. 79) P = 361°.6, D = 182″.5. D is Piazzi's star. The other three members of the group form Σ 196. I have retained Sm's letters and quadrants.

No. 22 OΣ 38 γ^2 *Andromedæ*

The angle of position would appear to be gradually decreasing. We have for comparison—

	°	″	
1865.67	P = 107.07	D = 0.596	Kn on 4 nights with 7⅓-inch refractor
65.68	106.92	0.604	Da on 1 night with 8-inch refractor
68.82	101.99	0.69	Br on 6 nights with 11¾-inch refractor, at Dunsink Observatory, Dublin
72.03	87.7		Sb on 1 night with 8¼-inch refractor, Rugby
72.67	101.34	0.6 est.	Kn on 1 night with 7⅓-inch refractor
73.81	95.9	0.5 est.	W & S on 1 night with 8¼-inch refractor, Rugby
73.94	93.9	0.46 est.	Gl on 1 night with 9⅓-inch refractor, at Mr Crossley's Observatory, Halifax
74.93	98.7	0.56 est.	Gl on 1 night with 9⅓-inch refractor

No 36 ζ *Persei*

In the Bedford Catalogue, Sm makes B the brightest of the companions To my eye they increase in brightness outwards He also gives the distance of C = 82″ 9 E is the small star added by H (2nd Series, No 337), P = 280° D = 25″, magnitude = 17 As the star is rather faint, my distance is probably too large

No 44 40 *Eridani* o²

A star remarkable for its large proper motion, in which its companion partakes B is itself double and a binary system, discovered by H in 1783 We have the following measures for comparison —

	°	″ ″	
1783 13	P = 326 70	D = 4—8	H on 1 night
1825 12	287 7		Σ on 1 night with 9 6-inch Dorpat refractor
1850 94	160 2	3 93	OΣ on 2 nights with 15-inch Pulkowa refractor
1851 06	159 96	3 ±	Da on 1 night with 6⅓-inch refractor
1851 50	160 2	3 85	OΣ on 2 nights with 15 inch refractor
1864 8	147 6	4 45	Winnecke
1871 99	125 ± est	2 ± est	Kn on 1 night with 7⅓-inch refractor

Σ looked for C in vain in 1835 and 1836, and suggests that its light may be variable I quote Winnecke's measures as given by Mr S W Burnham in the *English Mechanic*, No 513, January 22, 1875, p 464 My estimations of P and D must be regarded as rough approximations only

No 45 U *Tauri*.

This star, which is about a quarter of a degree to the north of the variable star T *Tauri*, Hind's variable nebula, and O Struve's new nebula (*Astr Nachr*, 1689) was judged to be variable by Mr Joseph Baxendell, F R A S, of Manchester, and was lettered by him accordingly I have examined the star occasionally at intervals, commencing with November 30, 1863, but have failed to notice any certain traces of change Happening, however, to be observing with a rather higher power than usual on December 4, 1867, I was surprised to find it to be a double star, with components nearly equal in magnitude The duplicity was also detected by D'Arrest on March 25, 1868 (?) (*Astr Nachr*, 1689) On March 21, 1871, Professor Schonfeld and Dr Tietjen, with the Berlin refractor, estimated the distance of the pair 4½″, and the angle of position 190° On December 22, 1876, I found the components equal in magnitude and sensibly unchanged

No 50 η *Orionis*

Although the various measures of this fine double star are not precisely accordant, there would not appear to be any decided indication of change since its discovery by the Rev W R Dawes on January 15, 1848

No 55 ψ^2 *Orionis*

Discovered by me to be double on February 21, 1863 It was measured by DAWES on two nights with the following results —

1863 86 P = 324° 00 D = 2″ 756

No 60 3 *Monocerotis*

This and the two following stars, 4 *Monocerotis* and LALANDE 12936, were discovered to be double by Mr S W BURNHAM, of Chicago, U S A, with a 6-inch ALVAN CLARK refractor, and form Nos 16, 17, and 19 of his "Catalogue of 81 Double Stars" printed in the *Monthly Notices of the Royal Astronomical Society*, vol xxxiii p 351

No 68 Neb H IV 45

Through some mistake, both H and SM place the 7 5 magnitude relatively to the Neb in the *n p* instead of the *n f* quadrant There seems to be no ground for suspecting any movement

No 106 R *Crateris*

A fine red star in the field with *α Crateris*, discovered to be variable by WINNECKE in 1861, and independently by BAXENDELL in 1866 It is one of the red stars in Sir JOHN HERSCHEL's Catalogue, on page 448 of the Cape Observations, where he describes it as "scarlet, almost blood colour" In the Bedford Catalogue, under *α Crateris*, SM gives the following description and measures, A being *α Crateris*, B the variable R *Crateris*, and C its blue neighbour

"A 4, orange tint, B 8, intense blood colour, C 9, pale blue"

"Position A B, 97° 0 (*w* 2) Difference Æ = 42^s 1 } Epoch 1835 38
" B C, 268° 2 (*w* 3) " = 4^s 9 }

No 118 *β Leonis*

In his "Second Series of Observations of Double Stars" (*Mem R A S*, vol xxxii), Mr E B POWELL, of Madras, gives the following measures of the star lettered B by me "P = 206° 5, D = 282″ 6, Ep 1861 16," and in his notes has these remarks —

"Admiral SMYTH assigns the *comes* a position angle of 114° and a distance of 298″, and states that the star is preceded by a 7th magnitude star in the *n p* quadrant The *comes*, however, is in the *s p* quadrant, and the 7th magnitude star is in the same quadrant beyond the *comes*, BC being by a very rough estimation about 3AB, and the position of C compared with A being 201° 5"

Mr POWELL is perhaps right in regard to SM's 8 mag companion, but it is worthy of note that the P and D of the small star E agree pretty closely with those assigned by SM to his *comes*

The magnitudes of the various stars in the group were carefully determined by me on several evenings by the method of limiting apertures, and the means of these determinations are the magnitudes assigned to the several stars in my "Mean Results"

On June 15, 1868, I swept over the field, and found it apparently unchanged I added a star 10¾ mag *s f* C, at about a distance from it = ½BC

No 145 61 *Virginis*

A star with a considerable proper motion, causing a change in the quadrant and a large increase in the distance of the *comes* since the date of its discovery by ♅

	°	″	
1783 0	P = 345 ±	D = 73 25	♅
1862 29	22 65	169 286	KN on 1 night

There would appear to be an error in the quadrant in the Bedford Catalogue Starting from ♅'s epoch, and applying proper motion, the angle of position at SM's epoch would be about 14° or 15°

No 176 11 *Scorpii*

Discovered by Mr S W BURNHAM, of Chicago, U S A It is No 39 of his "Catalogue of 81 Double Stars" in the *Monthly Notices R A S*, vol xxxiii p 351

No 205 OΣ 328 68 *Herculis*

A charming double star, pointed out to me by Mr BUCKINGHAM in June 1868 It is No 328 of the Pulkowa Catalogue The deep blue tint of the small star is very remarkable We have the following measures for comparison —

	°	″	
1851 71	P = 60 9	D = 3 83	M
1867 38	61 10	4 180	DE on 4 nights
1868 47	62 46	4 312	KN on 2 nights

No 207. Σ 2190 P XVII 163

This is one of the stars in a list of "Queries relative to Double Stars," by Sir J F W HERSCHEL, printed in the *Monthly Notices* for November 1871, the words of the query being, ' The measures of this star are very conflicting Σ (1829) makes position 33° 22, H (1830), by a sweep, 18° 4 (plainly written in original, and diagram agreeing), MADLER (1843), 33° 67, and DEMBOWSKI (1863), 23° 00 Which is right?" My angle of position agrees closely with DEMBOWSKI's

No 229 *Lyræ* 91 B. B A.C 6468

A charming miniature of *β Cygni* A, with a close companion overlooked by me, forms OΣ 525, and is thus measured by DEMBOWSKI P = 132° 80, D = 1″ 360, Epoch 1869 77. Of the wide pair DEMBOWSKI has the following measures —

1869 77 P = 350° 35 D = 45″ 430 DE on 2 nights

No. 230. Σ 2472, 2473. *Lyræ* P. XIX. 13.

A neat quadruple star measured as such by Σ and Sm., and made quintuple by the addition of a minute star between the pairs, to which attention was called by Mr. W. E. Jones, in the *Astronomical Register* for July 1866, but which had been observed in 1862 by a gentleman who signs himself "Observer," in a letter to the *Astronomical Register* for September 1865.

No. 235. Σ 2545. ♅ I. 13.

There has been some confusion in regard to the identification of ♅'s star, but this has been fairly cleared up by Dawes in the notes to his "Micrometrical Measures of Double Stars" (*Mem. R.A.S.* vol. xxxv.). ♅'s description of his I. 13, as "the last star of a telescopic trifolium, similar to that in the hand of *Aquarius*," leaves no doubt as to the star observed by him. Dawes gives P. xix. 186 as one of the synonyms of the star, but is here in error, Piazzi's No. 186 is the *first*, not the *last*, star of the trifolium. The N.P.D. in Dawes's Catalogue is too great by 10°.

No. 253. *π Capricorni.*

A neat double star discovered by Mr. S. W. Burnham on August 8, 1871, with a 6-inch Alvan Clark refractor. It is No. 60 of his "Catalogue of 81 Double Stars," *Monthly Notices, R.A.S.*, vol. xxxiii. p. 351.

No. 287. *γ Equulei.*

A neat double star discovered by me on July 9, 1867. A second *comes*, "excessively faint," is added by Mr. Burnham, P = 10°, D = 25″, both estimated.

No. 290. *δ Equulei.*

Owing to the proper motion of the principal star, there has been a gradual decrease in the angle of position, and increase in the distance of the companion, since the earlier epochs. OΣ finds A to be a very close double star. I failed to elongate it on July 9, 1867, although I tried various powers under favourable atmospheric circumstances.

No. 301. OΣ 489. *π Cephei.*

A troublesome star to measure, but seems to be a binary system.

	°	″	
1843.77	P = 330.0	D = 1.8	Sm. on 1 night.
1865.71	5.91	1.153	Kn. on 2 nights.
1867.12	14.76	1.267	De. on 5 nights.
1873.81	21.4	1.38	Sb. on 1 night.
1874.84	19.3	1.26	W. & Sm. on 1 night.
1874.91	19.8	1.24	Gl. on 2 nights.

No	Name of Star	Struve's [O Struve's] No	R A 1880	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
1	η Cassiopeiæ	60	0 41 46	32 49 0	125 28	10	54	275	6 736	6	24	275	4, 8	65 688	A *pale yellow*, B *ruddy purple*, obs not very satisfactory, air disturbed
2					126 69	6	34	275	6 745	6	30	275	4, 7 8	65 696	A *white* or *pale yellow*, B *ruddy purple*
3	…				125 16	6	44	275	6 771	8	45	275	4, 8	65 699	A *pale yellow*, B *ruddy purple*, aperture reduced to 5 inches
4	. . .. .				137 70	5	40	275	6 101	4	32	275		72 655	A *white*, B *lilac*, daylight, images a little confused
5	.				138 02	5	45	330	6 138	4	36	330	4, 7 5	72 655	A *white* or *very pale yellow*, B *pale purple*, later same evening as preceding measures, stars well seen, definition very good, lamplight
6	… ..	.			138 00	5	45	330	6 037	4	36	330	4, 7 5	72 658	A *white* or *very pale yellow*, B *pale purple*, clear and still, fine definition
7	. …	.	.		137 68	5	40	330	6 115	4	32	330	3 5, 7 5	72 661	A *white* or *very pale yellow*, B *pale purple*, brilliant, but at times images a little confused
8	36 Andromedæ .	73	0 48 32	67 1 2	344 86	5	30	375	1 323	6	30	375	6, 6 3	65 674	A *yellow*, B *bluish white*, well separated, the disks round and clean, moonlight
9	.	…			344 99	7	53	{375 {515	1 393	8	48	{375 {515	5 6, 5 9	65 696	A *pale yellow*, B *greenish yellow*, stars widely separated
10	.				344 67	6	42	375	1 322	6	36	375	5 5, 6	65 699	A *pale yellow*, B *greenish yellow*, vision nearly perfect, stars widely separated
11	Arietis, P I 222 AB	196	1 52 56	69 31 5	50 00	3	13		2½ est				9 5, 11 7	62 946	A quadruple group of which D is P I 222, lettered as in Bedford Catalogue, the colour of D is a *fine yellow*
12	AC				166 37	3	15	.	37 367	2	10		9 5, 10 3		
13	AD			.	0 80	3	12		183 68	1	4		9 5, 6 0		
14	α Piscium	202	1 55 50	87 49 0	327 18	4	18	360	3 077	5	19	360		64 014	Definition good, Barlow lens on micrometer
15					324 76	5	30	275	3 223	6	30	275		65·056	A *white*, B *yellowish white*

16						325 94	6	40	275	3 284	8	38	275	4 5, 5 5	65 666	A *very pale yellow*, B *bluish* a decided tint, aperture reduced to 4 inches
17		...	..	. .	...	326 33	5	43	275	3 205	6	42	275	4 3, 5 5	65 674	A *white*, B *grey*
18	γ Andromedæ,	A, $\frac{B+C}{2}$	205	1 56 32	48 14 7	63 64	5	39	375	10 359	4	24	375	...	65 647	A *orange*, B *green*, star disks not clean
19			.		...	63 69	8	53	275	10 053	8	40	275	.	65 661	A *orange*, BC as one star, *pale green*
20						62 95	8	64	275	10 551	10	60	275	..	65 666	A *orange yellow*, BC *pale green*, stars rather unsteady
21						63 69	4	36	275	10 410	4	28	275		65 696	
22		BC	[38]			106 33	4	12	375 515	0 6 est			375 515		65 647	
23						106 69	10	51	375	0 595	4	8	375	5, 6	65 661	Definition good, in mag B and C considerably unequal
24						106 87	10	52	515	0 567	6	18	515	6, 7	65 674	A *orange*, BC *pale green*, BC not divided but deeply notched, and the elongated disk crossed at times by a dark line, C much less than B
25						108 53	6	27	515	0 640	4	12	515	5 5, 7 0	65 696	A *orange*, B *pale green*, C *pale green*, rather deeper in tint, disks in contact, and rather crushed together, B and C of *bluish green* colour
26		.			.	101 34	4	16	515	0 6 est			515		72 666	Fairly seen at times
27	ε Arietis		333	2 52 21	69 8 4	199 06	5	23	375	1 103	4	12	375	.	66 636	Stars well separated, far from meridian
28	.					199 55	6	22	375				.	5 5, 6	66 701	Definition poor.
29						197 36	6	24	375	1 169	8	24	375	5 5, 6	66 710	Both stars *very pale yellow*, aperture reduced to 5 7 inches, star disks not clean
30		.				197 87	6	36	375 515	0 938	6	30	515	5 5, 6	66 729	Both stars *very pale yellow*, definition good
31	52 Arietis	...	346	2 58 24	65 12 7	271 54	5	25	375	0 796	8	32	375 515	6 5, 6 5	65 699	A *white*, B *bluish white*, two other *comites*—C 11 mag *blue* close to north vertical, D 12 5, following at a distance on the parallel, SM estimates C 15, D 13 mag
32						268 90	5	25	515	0 769	4	12	515		66 729	C 11 5, *blue*
33	7 Tauri	AB	412	3 27 20	65 56 3	60 80	4	16	375 515	0 55 est	...	..	515	7, 7	64 929	Stars not separated obs poor

No	Name of Star		Struves [O Struves] No	R A 1880	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
				h m s	° ′	°				″						
34	7 Tauri	AC	412	3 27 20	65 56 3	61 45				22 869				7, 10 7	64 929	A line through AB passes nearly over C
35	Camelopardi P III 97			3 32 49	30 25 2	34 32	5	35	115	55 642	10	60	115	6, 9	63 021	A *orange red*, B *blue*, a fine highly coloured pair
36	ζ Persei	AB	464	3 46 35	58 28 4	207 49	5	10		13 794	5	5		3, 11	60 803	B *blue*
37						207 06	5	12		14 343	5	10			60 874	The distance perhaps too wide
38		AC				197 03	5	10		90 266	5	5		10	60 803	Sm's distance is less by 7″, he also makes B 10, C 12, and D 11 mag respectively
39						199 17	5	15		90 157	7	14			60 874	
40		AD				184 67	5	14		122 100	5	10		9 8	60 803	
41						186 01	4	8		120 965	5	10			60 874	
42		AE				290 41	5	10		32 820	5	10		12 2	60 803	The small star discovered by Sir John Herschel
43						289 71	5	10		34 815	5	10			60 874	
44	40 Eridani	o²	518	4 9 49	97 48 7	106 97	3	27	160	80 772	4	32	160	5, 9 5	71 992	A *orange yellow*, B *bluish*, B has a small *comes* 10½ mag, distant about 2″ on an angle of 125° ±, there is also a minute 12½ mag star in the *s f* quadrant
45	U Tauri			4 14 49	70 28 2	202 10	1	2	275					9 7, 9 7	67 926	Obs interrupted by clouds *See* Notes
46						202 10	5	17	160 275	3 101	4	8	275	10 0, 10 1	68 099	A *slightly ruddy*, observation difficult in moonlight and among drifting clouds
47	β Orionis		668	5 8 46	98 20 5	197 92	6	35	275	9 297	6	26	275	1 5, 8 5	65 872	A *white* or *very pale yellow*, B *sky-blue*
48						198 82	5	22	275	9 866	4	20	275	1 3, 8 5	66 039	A *bluish white*, B *pale blue*, aperture reduced to 4½ inches, air disturbed and obs difficult
49						199 52	5	35	275	9 738	6	30	275	8 5	66 089	A *white*, B *pale blue*, aperture red to 4 inches, moonlight
50	η Orionis (D5)			5 18 27	92 30 5	87 60	5	15	610	0 988	10	20	610		63 116	Air tolerably still, Barlow lens on micrometer.

51	.. .	.	. .		89 65	10	27	610	0 907	10	22	610		63 127	A really fine night, Barlow lens on micrometer
52	...	..	.		88 41	5	30	515	1 080	4	10	375	4 5, 5 5	66 064	Dist meas very poor
53	.. .	.	.	.	89 83	8	36	515	1 021	6	24	515	4 3, 5 5	66 940	Both stars *greenish yellow*, definition fair
54	. .	.	. .	.	89 26	4	25	450	1 038	4	20	450	4 5, 5 5	71 992	Stars well seen at first
55	ψ² Orionis	,	5 20 33	87 0 6	322 12	5	11	275	2 556	10	20	275	5 5, 11 3	63 157	Discovered in sweeping on Feb 21, 1863, a neat double star, A *yellow*, B *blue*
56	.				322 38	10	23	275	3 129	10	20	275	11	63 160	B *blue*
57					322 11	7	36	275	2 729	8	38	275	5 5, 11	65 056	A *pale yellow*, B *blue*, a fine colour
58					320 71	5	15	255				.	5 5, 11 0	65 152	A *orange yellow*, B *blue*, observed with great difficulty, Barlow lens on micrometer
59	52 Orionis	795	5 41 33	83 35 3	198 95	6	18	360	1 600	10	17	360	..	63 064	Aperture red to 5½ inches, definition very bad, Barlow lens on micrometer
60	3 Monocerotis		5 56 12	100 36 1	356 13	3	15	450	1 797	4	16	450	10	72 138	Discovered by Mr Burnham of Chicago, U S A
61	4 Monocerotis AB		6 2 48	101 7 8	178 60	5	30	375	3 385	4	12	375	6 5, 10 5	72 138	B *blue*, discovered by Mr Burnham, the second and fainter of two
62	... AC	.			244 10	3	9	375	10 est				11 5	72 138	C a small companion added by myself
63	Lalande 12936 ..	..	6 36 36	105 53 6	169 42	3	21	375	4 071	4	16	375	7 2, 9 5	72 138	Discovered by Mr. Burnham, meas difficult from haze
64	α Canis Maj. (Sirius)	...	6 39 52	106 33 2	77 21	5	22	375	10 433	4	10	375	10	66 064	A *very white*, B *pale blue*, Clark's companion, bright moonlight, meas taken with tolerable ease, B not less than 10 mag
65	.. ..		...		77 04	5	10	275					...	66 089	A *bluish white*, B *pale blue*, aperture red to 6½ inches, Sirius well defined but very unsteady, B visible by glimpses with 5-inch aperture
66	Geminorum H V 66		7 20 30	67 36 1	276 92	5	40	115	35 894	6	37	115	7 5, 9 2	64 929	A *golden with rosy tinge* B *pale blue*
67	... ...	...	...		276 51	5	40	115	36 050	6	36	115	7 7, 9 3	64 948	A *golden orange* B *pale blue*
68	Neb H IV 45		7 22 6	68 50 9		.			100 840	4	20	115	8 3, 7 5	64 929	A, nebulous star, B *yellow* a third star 12½ mag in *n p* quadrant
69				.	2 84	5	34	115	100 110	4	12	115	8 7 7 7	64 948	Position angle of B 77, taken from A the nebulous star
70	.. ... .			.	2 48	6	51	115	100 260	6	32	115	8 5, 7 5	64 962	Obs interrupted by clouds

No	Name of Star	Struve's [O Struve's] No	R A 1880	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
71	Neb Ḣ IV 45		7 22 6	68 50 9	2 10	5	37	115	100 183	6	28	115	8 8, 7 5	65 009	B *yellow*, C 12 5 mag, hazy
72					2 35	5	43	115	99 707	6	36	115		65 056	Not well seen
73	α Geminorum Castor	1110	7 26 57	57 50 9	240 61	5	36	275	5 484	6	45	275		64 787	Measures by Capt Tupman, aperture reduced to 4½ inches, A *white*, B *yellow*
74					239 75	10	69	275	5 416	10	60	275	3, 3 5	64 962	A *very pale yellow*, B *greenish yellow*, definition very fine at times, aperture reduced to 5 inches
75					239 67	7	61	275	5 434	6	48	275	3, 3 5	65 056	A *pale yellow*, B *brownish yellow*, aperture reduced to 4 inches, star disks round and clean
76		••			238 84	7	59	275	5 603	6	50	275	2 7, 3 5	65 872	A *yellow*, B *brownish yellow*, deeper in colour than A, 4 inches aperture
77					240 49	7	56	275	5 726	4	30	275	3, 3 5	66 039	Aperture reduced to 4½ inches, both stars *greenish yellow*, B deeper in colour than A
78					237 06	4	36	275	5 703	4	36	275		71 992	
79					236 58	4	36	330	5 754	4	36	330		72 028	Both stars *pale greenish yellow*
80	Argûs Lalande 15219		7 42 18	105 43 1	311 09	10	77	115	127 817	10	69	115	6 5, 6 6	64 215	A fine *deep orange* coloured pair 1° 20′ S of 2 Arg Nav, to which my attention was called by the Rev T W Webb
81					310 31	9	63	115	129 217	10	69	115	6 3, 6 3	64 226	Definition not good, stars equal
82					310 60	10	90	115	129 144	10	80	115	6 5, 6 5	64 228	Both stars *fine orange yellow*
83	ζ Cancri A and B	1196	8 5 20	71 59 4	268 12	10	42	610	0 696	10	29	610		63 127	Disks almost in contact, Barlow lens on micrometer
84					238 24	8	45	360	0 638	4	14	360		65 319	Disks round and just in contact, Barlow lens on micrometer
85					244 43	6	20	375	0 6 est			375		65 371	Circumstances not good
86					242 46	8	27	375	0 6 est			375		65 392	A *pale yellow*, B *pale blue*, daylight, aperture reduced to 6 inches
87	...				237 34	8	53	{375 {515	0 825	10	56	{375 {515		66 135	Distance greater than last year? stars well divided

88		.			233 39	7	34	{375 515}	0 827	6	28	515		66 291	The stars separated, and I think not so close as last year, distance measure rather uncertain
89	.				232 33	10	45	375	0 782	8	32	{375 515}		66 302	Stars well separated, but definition poor
90		.			230 15	5	20	375	0 699	6	28	515		66 313	When best seen, stars separated, definition at times very bad
91					228 29	6	34	515	0 659	6	30	515		66 940	Definition good, stars just separated
92					166 52	4	24	515	0 6 est			515		72 088	Not separated?
93					166 93	5	35	515	0 6 est			515		72 138	I think the distance cannot be more than 0″ 6
94	A and C				143 96	8	46	610	5 236	10	47	610		63 127	Distance probably too wide, Barlow lens on micrometer
95	θ Cancri		8 24 45	71 30 0	59 30	5	15	115	58 407	4	8	115		62 313	Mag of B, 11 5 Sm rates it 9 mag Is it variable?
96	Cancri P VIII 129	1254	8 33 29	69 54 5	54 20	10	27	{115 160}					7, 9 7	62 168	A star with small companion It is at the southern apex of a triangle of stars, and is the brightest of the three
97	Ursæ Majoris	1387	9 45 11	20 29 4	272 07	4	7	160	9 045	7	13	160	10, 10	64 028	One of Σ's *Exiquæ* near the Neb M 81
98					271 25	4	14	160						64 037	One setting of wires gave D 8″ 873
99	Ursæ Majoris	1386	9 45 11	20 32 1	295 76	5	16	275	1 608	10	22	275	8 5, 8 5	64 037	A bright, close pair, near Neb M 81, evening still and definition good
100	γ Leonis	1424	10 13 21	69 33 1	109 11	6	54	375	3 152	6	54	375		66 135	A *golden yellow*, B *greenish yellow*, a delicate colour, definition very good
101					112 18	5	36	275	3 260	6	41	275	3, 4	66 193	A *pale yellow*, B *pale green*, aperture reduced to 4 inches
102					110 83	5	39	275	3 260	4	26	275	3, 4	66 291	Well seen, full aperture
103	..	.			111 80	5	32	330	2 894	4	20	330	2 5, 4	71 372	A *full yellow* B *greenish*, daylight, disks disturbed at times
104	.	.			113 45	5	34	330	2 711	4	20	330	2 3, 4	71 387	A *full clear yellow*, B *pale grey green*, daylight, 4 inches aperture
105	.				112 85	5	41	330	3 321	4	32	330		71 390	A *full yellow*, B *greenish grey*, 4 inches aperture, good definition but a little unsteady
106	R Crateris		10 54 40	107 40 8	268 19	6	42	160	65 335	6	30	160	8 4	66 346	A fine red star in field with α Crateris, by Winnecke discovered to be variable, which is confirmed by Baxendell, A *orange red*, B *blue*

No	Name of Star.	Struve's [O Struve's] No	R A 1880	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
107	R Crateris		10 54 40	107 40 8	268 82	5	40	275	66 215	8	40	160 275	8 3, 9 7	66 370	A *orange red*, B *blue*, twilight, stars rather faint
108					268 42	6	42	160	66 342	6	30	160	8 3, 10	66 376	A *fine ruddy*, B *bluish*, full twilight
109	ξ Ursæ Majoris	1523	11 11 48	57 47 4	31 18	6	35	450 515	1 092	6	30	515		72 028	*White* both stars, vision rather disturbed
110					29 69	5	29	450 515	1 111	4	24	515		72 088	Both stars *pale white*, generally well seen, at times a little confused
111					28 15	5	36	515	1 052	4	24	515	4 8, 4 8	72 138	*White* both stars, well seen, a heavy dew
112					19 99	5	35	515	1 189	4	24	515		72 403	Stars rather far from meridian, new webs to micrometer rather thicker than the old ones, distance fully large, estimated about 1′
113					13 60	5	30	450	1 075	4	24	450		72 456	Daylight, images at times much disturbed
114					16 36	6	36	450	1 066	4	24	450		72 456	Later on same evening as preceding measures, images disturbed at times, but better seen, lamplight
115	ν Ursæ Majoris	1524	11 12 0	56 15 1	144 06	5	40	275	7 304	4	28	330	4 5, 10 3	72 028	A fine coloured pair A *orange yellow*, B *blue*
116					143 55	5	40	275	7 030	4	24	275	10 5	72 088	A *golden yellow* B *blue* obs not easy from disparity of components
117					146 51	5	45	330	7 272	4	32	330	4, 10	72 138	A *golden with rosy flush*, B *clear blue*, stars well seen, bright moonlight
118	β Leonis, A and B		11 42 56	74 45 4	206 15	2	18	115	282 473	2	14	115	8	64 368	
119					206 44	5	45	115	282 399	5	35	115	8 3	64 431	Daylight
120	A and C				186 80	2	14	115	690 ±					64 368	The distance approximate only, taken with reticular eye-piece, probably too large
121	A and D				201 55	2	18	115	1134 3					64 368	The distance by the teeth of the comb of micrometer, at Epoch 1864 45
122	A and E				116 27	5	13	115	303 924	8	16	115	11 7	64 373	

123					115 54	5	15	{115 160}	304 001	3	6	{115 160}		64 376	Moonlight and star some hours from meridian
124					115 06	5	15	{115 160}	303 732	5	10	{115 160}		64 379	E is close to the place of Admiral Smyth's star
125					1 15 14	5	25	115	302 743	4	16	115		64 381	Moon nearly full, very bright
126	A and F				116 17	3	20	115	556 439	2	6	115		64 381	
127	A and H				318 63	3	12	115	545 499	3	6	115	10	64 425	H has a minute *comes* to the *n p*
128	A and K				302 60	3	12	115	692 919	2	4	115	10	64 425	Sky hazy
129	F and G				21 70	4	11		50 585	2	4			64 381	
130	[illegible]	1670	12 35 36	90 47 5	168 77	5	26	275						60 395	
131					1 9 54	10	51	160						60 452	Full aperture, daylight
132									4 086	10	50	160		60 455	Daylight
133									4 011	10	50	275		60 463	Daylight, air very unsteady
134					164 56	10	65	375	4 416	10	47	375	4, 4	64 431	A *yellowish*, B *greenish yellow*, B is perhaps rather the brighter star
135					166 20	10	61	275	4 148	10	54	275		64 450	A *yellow*, B *greenish yellow*, aperture 4½ inches, A rather deeper in colour and rather brighter than B, a small star, 10 mag, at a distance to the south, very near the vertical
136					163 87	7	62	275	4·349	10	69	275	3 5, 3 7	65 431	A *yellow*, B *greenish yellow*, daylight, well seen, 4½ inches aperture
137					164 80	10	76	275	4 285	10	72	275	3, 3	65 456	Before sunset, aperture 4 inches
138					164 25	10	78	275	4 382	8	56	275	3, 3	65 469	Daylight, aperture for P 5½, for D 4 inches
139					160 59	5	30	275	4·998	6	30	275		71 373	A slightly less in mag and rather deeper in colour than B
140					158 58	5	35	330	4 446	4	28	330	3, 3	71 387	Aperture 4 inches
141					160 19	5	45	330	4 202	6	48	330		71 390	Aperture 4 inches
142					161 45	5	40	330	4 825	4	32	330		72 403	New webs to micrometer, rather thicker than the old, about 0″ 6 in diameter, clear and still, stars well seen, both *pale yellow*
143	35 Comæ Beren AB	1687	12 47 23	68 6 1	52 87	5	20	360	1 314	4	14	360	5, 8 5	65 313	A *pale yellow*, B *pale blue*, Barlow lens on micrometer
144	AC				124 86	4	33	360	28 318	4	24	360	5 10	65 313	C *bluish*
145	61 Virginis		13 12 10	107 38 0	22 65	6	18	115	169 286	5	15	115		62 285	

No	Name of Star	Struve's [O Struve's] No	R A 1880	N P D 1880	Position	Obs.	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
146	Bootis	1785	13 43 38	62 25 1	199 26	6	30	330	2 695	6	30	330	7 3, 7 8	71 372	A *very pale yellow*, B *bluish*
147					200 11	5	25	275	2 400	4	16	275	7 5, 8	71 387	A *white*, B *bluish*, definition very bad
148					198 48	5	30	330	2 333	4	20	330	7 8, 8	71 390	A *white*, B *grey blue* images at times confused, the two stars as one gauged 7 5 mag, but observation a little doubtful
149	ζ Bootis	1865	14 35 25	75 45 4	303 14	5	40	375	0 971	8	56	375	4, 4	70 466	Both stars *pale yellow*, well separated, daylight
150	ε Bootis	1877	14 39 45	62 25 2	323 97	6	36	330	2 730	6	24	330		67 335	A *full yellow*, B *greenish blue*, stars rather unsteady
151	Coronæ Bor 1 B	1932	15 13 12	62 43 5	288 80	4	16	275	1 345	4	16	275		63 784	Definition very bad
152	η Coronæ Borealis	1937	15 18 15	59 16 5	36 58	6	33	450	1 070	4	20	450	6 5, 6 8	67 332	Both stars *pale greenish yellow*, well separated and pretty well defined
153					35 56	6	23	450	1 129	6	18	450		67 335	Vision at times very much confused, stars very nearly equal
154					35 74	6	30	450	1 019	6	30	450	6 5 6 8	67 346	Both stars *pale yellow*, vision at times very confused, a small star, 12 mag, at a distance in the *n f* quadrant
155					46 85	4	32	375	1 134	6	42	375		70 466	Both stars *white*, a little wider, I think, than ζ Bootis, well separated
156					45 93	5	32	450	1 039	6	30	{450 {515		71 494	I think closer than when last observed, clear and still, bright moonlight
157					46 39	6	27	450	0 947	4	16	450		71 507	Hazy, images very confused
158					44 54	5	36	515	0 983	4	28	515		71 540	A fine night after an intensely hot day, stars well seen
159					46 29	5	37	515	1 079	4	28	515		71 581	Both stars *white*, definition good, but stars a little unsteady
160					45 29	5	33	450	0 928	4	24	450		71 598	Definition at times very good
161	μ Bootis A & $\frac{B+C}{2}$		15 19 58	52 12 2	171 66	3	27	375	108 323	2	18	375		64 343	Definition good
162					171 18	5	45	375	108 192	5	35	375	4 8 8 5	64 425	A *golden*, B & C both *bluish*
163					171 51	5	45	360	108 137	5	40	360		64 436	Barlow lens on micrometer
164	μ- Boot P XV 74	1938	15 19 59	52 14 0	197 10	10	46	{375 {515	0 5 est			515	7 8, 8 5	64 343	Stars not divided, but notched

165					190 55	6	17	515	0 5 est			515		64 425	Elongated and notched
166					193 62	10	33	{360 610}	0 5 est			{360 610}		64 436	Barlow lens on micrometer, stars not separated, definition not good
167					191 78	10	57	375	0 55 est			375	8, 8 3	64 442	Stars not separated
168					152 04	5	25	515	0 6 est			515		72 456	Stars rather faint and vision disturbed, nearly, if not quite separated
169	δ Serpentis	1954	15 29 5	79 3 5	189 09	6	35	275	3 696	6	32	275	4, 5	65 398	A *white*, B *blue*, air a good deal disturbed
170					190 40	10	83	275	3 235	10	72	275	4, 5	65 412	A *white*, B *blue*, a fine colour, aperture 4½ inches
171					189 83	6	53	275	3 232	10	65	275		65 428	
172	ξ Scorpii A and B	1998	15 57 46	101 2 4	166 50	5	26	515	0 997	4	23	515		68 483	Vision rather confused, stars slightly unequal
173	...				176 92	5	30	450	1 121	4	20	450		72 456	Stars well severed
174	♅ II 21 A and B	1999	15 57 50	101 7 0	98 88	5	33	160	11 266	4	24	160	8, 8 5	65 398	Pair to south of ξ Scorpii, air much disturbed, and stars at times much obscured
175	B and C				77 05	4	14	160	61 105	4	8	160	8 5, 11	65 398	Hazy, C small star noted by Mr Brothers
176	11 Scorpii		16 0 57	102 25 2	258 20	4	25	330	3 750	4	20	330		72 551	A *white*, B, 10¼ mag, *bluish*, discovered by Mr Burnham, vision disturbed, obs rather difficult
177	σ Coronæ Borealis	2032	16 10 12	55 50 1	194 54	3	21	330	2 854	4	28	330		67 332	A *pale yellow*, B *clear pale blue*, a third star, 10 7 mag, *bluish*, on angle of 91°
178					193 97	5	28	275	3 128	4	16	275		67 335	Vision much disturbed at times
179					194 71	4	28	330	3 010	4	24	330	6, 6 7	67 346	A *very pale yellow*, B *pale blue*, C, 11 mag, *dusky*, P = 89° 77, D = 52″ 14
180					196 09	5	43	330	3 022	4	32	330		71 494	A *very pale yellow*, B *clear blue*, to the senses obs very satisfactory
181					195 09	5	40	330	3 225	4	24	330		71 507	A *white*, B *blue*, hazy
182					194 73	5	45	330	3 307	4	28	330		71 540	A *pale yellow*, B *clear sky-blue*, definition at times perfect
183					195 48	4	32	330	3 366	4	32	330		71 598	A *white*, B *pale blue*, stars a little unsteady but at times remarkably well seen

No	Name of Star	Struve's [O Struve's] No	R A 1880	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
184	α Scorpii (*Antares*)		16 22 3	116 9 8	272 80	1	5	375	3 796	2	8	375		64 428	A *orange red*, B *fine pale blue*, obs closed by sea fog, which obscured the stars
185					278 66	10	53	360	3 190	10	50	375		64 436	A *ruddy orange*, B *blue*, the spectrum of the large star rendered measurement of angle of position difficult, Barlow lens
186					272 08	6	17	275	3 604	4	6	275	1, 7 8	64 450	A *fiery orange*, B *blue*, large star unsteady but free from spectrum, 6½ aperture
187					274 38	10	60	275	3 528	10	28	275	1, 7 5	64 450	A *fiery orange* B *clear blue*, measures taken later same evening as preceding, at times neatly defined, 6½, 5½, and 4½ inches aperture
188	ζ Herculis	2084	16 36 47	58 10 9	204 46	5	23	515	0 951	4	8	515		68 401	A *pale yellow*, B *greenish*, B a *greenish* spot on or slightly within first bright ring of A
189					206 95	5	23	515	1 088	4	16	515		68 456	A *pale yellow*, B *greenish*, 7 mag, just on or just within first bright ring of A
190					208 19	6	33	515	1 025	4	22	515	3, 6 5	68 476	A *very pale yellow*, B *orange*, at times very well seen, on first bright ring of A, with full aperture
191					205 90	5	27	515	0 896	4	20	515		68 608	Obs difficult through unsteadiness of images
192					183 81	5	21	515	1 028	4	16	515		71 494	Vision deteriorating, B an *orange* tinted spot on first bright ring of A
193					182 69	5	22	515						71 507	Distance measures impossible, images very disturbed
194					184 81	6	39	515	1 066	4	28	515		71 540	A *pale yellow*, B *deep brownish orange*
195					182 53	5	37	515	0 919	4	24	515		71 581	Pretty well seen at times, but images a good deal disturbed
196					182 73	5	37	515	1 061	4	24	515		71 598	B well seen at times as an *orange* spot on first bright ring of A

197	Herculis 210 B	2120	17 0 0	61 44 6	263 92	5	29	330	3 966	4	22	330	7, 10	71 494	A *ruddy?* B *deep blue*, position circle set to 270°, but setting intolerable
198					263 52	5	26	330	3 866	4	20	330	7, 10	71 507	A *pale yellow* with *rosy flush*, B *deep blue*, well seen at times, B faint
199					262 64	4	32	{275 330}	3 773	4	24	275		71 540	A *tawny*, B *clear blue*, at times stars obliterated by cloud
200	δ Herculis	3127	17 10 6	65 1 0	179 46	7	60	275	20 275	6	42	275	4 2, 8 5	66 710	A *yellow*, B *grape red*, well seen, stars very considerably unequal
201					179 75	8	64	275	20 097	6	36	275	3 5, 8 5	66 737	A *pale yellow*, B *ruddy lilac*
202					180 45	5	45	275	19 438	4	36	275	8 5	71 598	A *pale yellow*, B *ruddy purple*, very well seen
203					179 95	5	35	275	19 818	4	28	275		71 600	Images very disturbed and distance measures difficult
204					180 35	5	45	275	18 848	4	36	275		71 606	Definition almost perfect
205	68 Herculis	[328]	17 12 54	56 46 2	61 86	6	41	330	4 281	4	24	330	4 5, 11 5	68 456	A *clear pale yellow*, B *deep indigo blue*, an exquisite double star pointed out to me by Mr Buckingham, it is however No 328 of the Pulkowa Catalogue
206					63 05	6	42	330	4 339	4	28	330	5, 11	68 476	A *pale yellow*, B *deep blue*, observation rather difficult from disparity
207	Herc P XVII 163	2190	17 30 52	68 55 6	23 36	4	32	160	9 632	2	16	160	6, 9 5	72 403	A *pale yellow*, B *lilac* *See* Notes
208	μ Herc A & $\frac{B+C}{2}$	2220	17 41 47	62 12 1	243 70	4	34	275	31 357	4	24	{160 375}	4, 10 2	65 431	A *yellow*, B *bluish white*
209					244 02	5	41	255	31 304	6	42	255	10	65 434	A *yellow*, a rather fine tint, B & C *bluish white*, very good definition, Barlow lens
210	B and C				83 29	5	15	{275 375}					10 8, 10 8	65 431	Extremely difficult, distance measures impossible, stars at times well seen
211					77 77	6	29	360	1 838	6	12	360	10 5, 10 7	65 434	Both stars *bluish white*, the preceding star the larger, a most delicate object, the distance measures mere guesses at times well seen, Barlow lens on micrometer
212	95 Herculis	2264	17 56 25	68 24 1	260 53	5	38	330	6 381	4	24	330		67 390	A *pale green*, B *clear orange red*, but little difference of mag, the following star rather the brighter
213					260 18	5	45	330	6 354	4	32	330	5 3, 5 5	67 392	A *pale green* B *clear pale orange red*

No	Name of Star	Struve's [O Struve's] No	R A 1880	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
214	τ Ophiuchi	2262	17 56 33	98 10 7	246 90	8	24	610	1 215	10	18	610	5 5, 6	63 532	Definition fair, Barlow lens on micrometer
215					245 63	10	20	360	1 133	10	20	360	5 8, 6	63 534	Still and hazy, Barlow lens on micrometer
216					246 03	7	20	360	1 205	8	15	360	5, 6	63 555	Barlow lens on micrometer
217					247 66	10	50	375	1 226	10	39	375		63 658	A *pale yellow*, B *deeper yellow*, at times *ruddy*
218	70 (*p*) Ophiuchi	2272	17 59 23	87 27 7	99 63	5	40	330	5 338	4	28	330	4 5, 7 0	67 392	A *pale yellow*, B *ruddy lilac*
219					99 98	5	40	330	5 101	4	28	330	4 5, 7 0	67 488	A *pale yellow*, B *ruddy lilac*, still and clear, stars not far from meridian
220					98 19	5	40	450	5 013	4	32	450	4 5, 6	68 516	A *pale yellow*, B *ruddy lilac*, 4½ in aperture, vision much disturbed
221					98 78	5	45	330	4 943	4	32	330		68 609	A *clear pale yellow*, B *ruddy lilac*, among clouds, definition good in the intervals
222					95 81	4	36	330	4 327	4	32	330		71 581	A *pale yellow*, B *ruddy lilac*, a good deal of disturbance, bright moonlight
223					94 57	4	36	330	4 304	4	36	330		71 598	A *pale yellow*, B *ruddy lilac*, stars well seen
224					94 35	5	35	330	4 263	4	24	330		71 600	Wind N E, stars mould and wrinkle
225	40 Draconis	2308	18 9 1	10 1 1	234 76	4	35	275	20 377	4	32	275	5 5, 6	65 842	Both stars *very pale yellow*, moonlight
226	α Lyræ		18 32 53	51 19 6	153 09	5	25	160	44 731	4	10	160	1, 10	65 762	A *dazzling bluish white*, B *blue*, troublesome to measure from disparity
227					150 84	4	28	275	46 308	4	22	275	1, 10	65 842	A *brilliant bluish white*, B *pale blue* or *lilac*, well seen, moonlight
228	θ Serpentis	2417	18 50 15	85 57 1	103 68	4	32	160	22 009	4	28	160	4 5, 5	65 842	A *yellow*, B *greenish yellow*
229	Lyræ 91 B B A C 6468		18 50 29	56 11 0	350 19	6	54	115	45 570	4	36	115	6, 7 3	65 762	A *yellow*, B *blue*, a charming miniature of β Cygni, the colours very fine

230	Lyræ P XIX 13	A and B	2472	19 4 24	52 16 8	337 61	3	24	160	18 478	2	14	160	8 3 10 2	68 516	Measures difficult in bright moonlight and haze, not able to measure the small star (12½ mag *bluish white*) on line from A to B, carried beyond to about ½ dist to C D, which makes the group quintuple
231		A and C				348 58	2	18	160	76 747	2	8	115		68 516	
232		C and D	2473			294 00	3	19	160	7 012	4	18	{160 275}	9 5, 9 5	68 516	
233	β Cygni			19 25 53	62 17 5	55 73	4	36	330	36 864	4	36	330		71 723	A *golden yellow*, B *greenish blue*, well seen, but a little unsteady
234						55 88	5	45	275	33 800	4	36	275		71 773	At times rather disturbed
235	H I 13		2545	19 32 8	100 25 6	317 88	4	20		3 922	7	21		7 5, 9	62 770	Distance probably too wide, it has a small *comes* 12 or 12½ mag on angle of 170°
236						317 45	6	30	255	3 505	7	28	255	7 3, 8 5	62 773	Barlow lens on micrometer, the third star, 12 or 13 mag, distant 20″ ± on angle of 170°
237	δ Cygni		2579	19 41 13	45 9 7	349 24	7	37	515	1 754	8	25	375	8 8	65 430	A *white* or *very pale yellow*, B *blue*, evening very clear and the small star well seen
238						348 88	10	75	610	1 685	10	60	610	3, 8	65 434	Barlow lens, A *white* or *pale yellow*, B *blue*, B well seen
239						348 16	7	23	515	1 738	6	19	{375 515}	8 8	66 636	Definition fair, but rather confused, moonlight
240						348 48	7	20	515	1 662	6	18	515	3 5, 8 5	66 729	A *clear yellow*, B *blue*
241						338 72	5	22	515	1 875	4	16	515		71 606	B *blue*, obs very difficult, the small star only seen at intervals, measures uncertain
242						338 06	5	25	515	1 633	4	20	515	9	71 778	B *bluish*, at times well seen, but measures made with difficulty
243						337 72	6	33	515	1 637	4	20	515	8 8	71 781	B *blue*, still, obs made with tolerable ease
244						337 30	4	24	{450 515}	1 660	4	24	450	9	71 809	A *pale yellow*, B *pale blue*, very well seen at times
245						330 24	6	30	515	1 692	4	20	515		72 666	Fairly seen at times
246	π Aquilæ		2583	19 43 3	78 28 8	122 50	7	33	375	1 503	8	31	375	6, 6 4	65 661	Both stars *white*, a line from B to A points to a small star-speck in the *n p* quadrant
247						121 90	6	23	275	1 363	8	24	275	6 6 4	65 666	A good deal of disturbance, C not seen
248						119 87	8	59	375	1 363	8	53	375	6 6 3	65 674	A *white* B *bluish white* C lost in bright moonlight

No	Name of Star	Struve's [O Struve's] No	R A 1880.	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
249	π Aquilæ (*cont*)	2583			122 06	5	24	{275 375}	1 446	4	16	375	6, 6 3	65 696	A *white*, B *greenish white*, C *pale blue* C nearly on line from B over A, 12 mag , distance 20″ ±
250	P XX 26	2644	20 6 28	89 29 4	211 73	6	46	275	3 403	8	48	275	7 1, 7 2	65 431	Both stars *bluish white*, very nearly if not quite equal, the two together as one star gauged 6 4 mag
251	.	. .	..	..	210 83	5	44	255	3 346	8	64	360	7 3, 7 3	65 434	A *bluish white*, B *pale blue*, Barlow lens on micrometer
252					211 16	9	65	275	3 483	8	39	275	7 2, 7 2	65 463	Both *bluish white*, sensibly equal, or nearly so, set wires to P = 208°, but the setting could not be tolerated, aperture 5½ inches
253	π Capricorni		20 20 27	108 36 2	144 57	6	35	{275 330}	3 041	4	20	330	6, 10 5	71 778	A *pale yellow*, B *pale blue*, the stars being at a low altitude, the measures are difficult, discovered by Mr Burnham
254	.				145 47	7	35	275	3 266	4	20	275	10	71 781	A *pale yellow*, B *bluish* at times very well seen, set the wires to 135°, but setting intolerable
255	.. ..	. .			144 65	5	25	330					6, 10 5	71 809	Set wires to 135°, but setting quite intolerable, distance measures impossible
256	ρ Capricorni		20 22 1	108 12 5	174 26	6	48	330	3'412	6	36	330	5, 8 3	71 809	A *pale yellow*, B *clear sky-blue*, definition good at times, but at times stars almost obliterated
257	Delphini H II 66	2725	20 40 37	74 32 0	356 85	7	36	275	5 132	6	24	275	7 2, 7 8	65 762	Both stars *white*, much disturbed, definition very poor
258					358 25	7	48	275	5 054	6	36	275	7 5, 8 2	65 781	A *white* or *very pale yellow*, B *pale blue*
259	γ Delphini	2727	20 41 6	74 18 3	272 74	5	44	275	11 732	4	32	275	4, 5	65 781	A *orange yellow* , B *green*, with perhaps a dash of *blue* in it, well seen colours very fine
260	Equul P XX 376	2735	20 49 40	85 55 5	286 23	5	32	375	2 107	6	33	375	6 5, 8	65 718	A *pale yellow*, B *lilac*, well seen, but unsteady

261					286 37	10	56	375	2 135	6	24	375		65 723	A *pale yellow*, B *lilac*, rather unsteady, set wires to P = 289°, setting slightly but decidedly too large
262					287 41	6	36	375	2 089	6	24	375		65 781	A *pale yellow*, B *lilac*, rather unsteady
263	ε Equulei A and B	2737	20 53 5	86 9 9	288 17	5	17	835	1 042	10	28	835	6, 6 3	63 658	Sky hazy, definition not good, Barlow lens on micrometer
264	· ·			·	286 42	10	26	360	0 972	10	16	360		63 666	Bad definition, 6 inch aperture, Barlow lens on micrometer
265					289 70	10	60	375	1 174	10	42	{375 515}	6, 6 2	64 743	Both stars *white* or *very pale yellow*, disks round and clean
266					291 16	10	67	360	1 069	10	52	360	6, 6 3	64 746	Both stars *white*, images a little confused, Barlow lens
267					289 48	7	46	375	1 098	6	29	375	6 3, 6 7	65 647	Both stars *white*, new fine webs to micrometer 0″ 4 in thickness, definition fair, close to meridian
268					287 63	8	46	375	1 116	6	30	375	6, 6 2	65 674	Stars well seen, *bluish white*
269					287 88	6	34	375	1 048	4	20	375	5 7, 6 0	65 696	Stars *white*, well separated
270	·				287 14	6	39	375	1 029	6	30	375		65 699	Stars neatly severed
271					288 03	3	15	375						65 781	Set wires to 285°, but angle to my eye evidently too small
272	A and C	2737	20 53 5	86 9 9	75 58	3	18		10 387	5	25		6, 8	63 658	
273	$\frac{A+B}{2}$ and C				77 64	7	48	275	11 196	8	44		8	64 743	C decidedly *bluish*, definition pretty good
274	$\frac{A+B}{2}$ and C				77 64	5	41	360	11 000	6	32	360	8	64 746	C *pale blue*, hazy, Barlow lens
275	A and C				75 95	3	24	375	10 556	4	28	375	6 3, 7 8	65 647	C *pale blue*, definition fair
276	A and C				75 79	5	40	375	10 744	4	26	375	6, 7 7	65 674	C *lilac*, good definition, close to meridian, moonlight
277	A and C				75 67	3	24	375	10 461	4	28	375	6 0, 7 8	65 699	A *greenish white*, B *greenish white*, deeper, C *purple*, stars well seen
278	2 (λ) Equulei	2742	20 56 18	83 17 4	224 45	6	42	375	2 712	6	30	375	6 5, 6 7	65 718	Both stars *bluish white*, B rather deeper in tint of the two, at times pretty steady
279					224 85	7	42	275	2 490	8	33	275		65 723	Rather unsteady
280	61 Cygni	2758	21 1 31	51 50 4	111 86	5	45	275	18 751	6	48	275	5 5 6	65 710	A *full yellow*, B *orange*, [illegible] the colour of B deeper than that of A

No	Name of Star	Struve's [O Struve's] No	R A, 1880	N P D 1880	Position	Obs	Weight	Power	Distance	Obs	Weight	Power.	Mags	Epoch 1800+	Remarks
			h m s	° ′	°				″						
281	61 Cygni (*cont*)	2758	21 1 31	51 50 4	111 52	5	45	275	18 765	6	48	275	5 5, 6 2	66 729	A *full yellow* B *deeper yellow*, 4-inch aperture
282					113 84	4	36	275	18 867	4	36	275		71 598	A *orange yellow*, B *deeper orange yellow*, about ½ mag difference between the stars
283					113 27	6	54	275	19 699	4	36	275		71 606	Stars exceedingly well seen
284	. . ... .	.			113 29	4	36	275	18 935	4	36	275		71 611	Good definition, both stars *full yellow*, the smaller fully ½ mag less than the larger star, and rather deeper in hue
285	... .	..	.		114 60	6	42	275	19 667	6	36	275		73 003	The smaller star the deeper in colour, images very confused at times, one of the fine webs broken, used stout webs for distance
286	. ...	.	.		114 31	6	42	275	19 521	4	28	275	5 5, 6	73 006	A *yellow*, B *deeper yellow*, cloudy at times, stout webs for distance, last measures at Woodcroft
287	γ Equulei		21 4 30	80 21 0	276 83	5	25	375	2 173	4	12	375	4 5, 11	67 518	A *pale yellow*, B *clear blue*, an exquisite double star, the most northerly of two preceding δ Equulei, distance measures difficult
288					276 85	6	28	450	2 089	4	12	450	5 0, 11 0	67 567	A *pale yellow*, B *blue*, a little hazy, and observation not easy
289					277 62	5	15	450	1 875	4	12	450	11	71 606	B *blue*, only to be seen on the most careful scrutiny, obs most difficult
290	δ Equulei	2777	21 8 38	80 28 5	27 67	7	45	275	34 488	8	40	275	4 5, 10 3	65 718	A *pale yellow*, B *lilac*, mag of B gauged, a good deal of disturbance
291					27 35	5	33	275	34 436	6	28	275	4 5, 10 3	65 723	A *pale yellow*, B *purple*, the small star at times invisible, rather unsteady
292	Pegasi 29 B	2804	21 27 26	69 49 0	325 13	4	32	330	2 903	6	48	330	7 5, 8	71 778	Both stars *white*, clear sky
293			...	.	325 02	4	32	275 330	3 051	4	32	275 330	7 5 8	71 781	*White* well seen, air hazy but still, definition pretty good
294	κ Pegasi ...	2824	21 39 13	64 54 4	304 86	5	20	275	11 929	3	9	275	10 3	62 447	B *pale blue*, improved by red illumination, bright moonlight, star 4 hours from meridian

295	ζ Aquarii	2909	22 22 39	90 38 0	337 58	6	37	275	3 677	6	32	275	4 3, 4 5	66 701	Both stars *white* and nearly equal
296					335 94	5	35	275	3 681	6	36	275	4 3, 4 5	66 710	A *very pale yellow*, B *greenish yellow*, 5 inches aperture
297					337 51	6	38	275	3 564	6	30	275		66 729	A *pale yellow*, B *pale greenish yellow*, 4 inches aperture, stars a little unsteady
298					334 26	5	45	375	3 380	4	36	375		71 606	Stars equal, both *pale yellow*
299					333 23	5	45	330	3 362	4	36	330		71 611	Stars equal, or nearly so, both *white*, fine definition
300					333 29	5	40	330	3 288	4	28	330		71 620	Images rather disturbed
301	π Cephei	[489]	23 4 5	15 15 7	5 23	5	10	375	1·153	4	8	375	5, 9	65 705	Definition execrable, and measures little more than guesses, a star 10½ mag follows by 34^s south of the parallel and a minute star 13 mag precedes at a less distance, on angle of 240° ±
302					6 50	5	14	515	..					65 716	Air so disturbed that distance measures are impossible
303	Cassiopeiæ	3057	23 58 43	32 8 1	298 55	6	18	360	3 574	6	8	360	7 3, 10 5	63 524	A *white*, B *deep blue*, forming with Σ 3062 a neat double double star *s p* β Cassiopeiæ, between the pairs, at about middle distance, lie three small stars of 9, 9½, and 11½ mag, Barlow lens
304	Cassiopeiæ H I 39	3062	23 59 57	32 14 0	265 70	6	16	360	1 407	10	20	360	7 5, 8 0	63 524	Both stars *yellow*, a binary star in field with preceding, from which it is distant 690″ on angle 119° 65
305					269 60	8	47	375	1 431	6	35	375	6 5, 7 0	65 699	A *white* or *very pale yellow*, B *bluish white*, the two stars nearly on the parallel
306					270 37	7	33	275	1 463	8	32	275	6 6, 7 2	65 701	Stars almost precisely on the parallel
307					270 01	7	45	375	1 411	8	45	375	6 5, 7 0	65 716	A *pale yellow*, B *bluish*, stars sensibly on the parallel
308	..	...			282 59	4	24	375	1 345	4	20	375		72 655	
309				.	282 80	4	28	450	1 418	4	20	450	7 8	72 658	A *bluish white*, B *bluish*, well seen on the whole, at times rather confused

Mean Results

Name of Star	Struve's [O Struve's] No	R A 1880	N P D 1880	Position	Nights	Obs	Weight	Distance	Nights	Obs	Weight	Mags	Epoch 1800+
		h m s	° ′	°				″					
η Cassiopeiæ	60	0 41 46	32 49 0	125 60	3	22	132	6 755	3	20	99	4, 8	65 69
				137 86	4	20	170	6 097	4	16	136	3 9 7 5	72 66
36 Andromedæ	73	0 48 32	67 1 2	344 85	3	18	125	1 353	3	20	114	5 7, 6 1	65 69
Arietis, P I 222 A and B	196	1 52 56	69 31 5	50 00	1	3	13	2½ est	1			9 5, 11 7	62 95
A and C				166 37	1	3	15	37 367	1	2	10	9 5, 10 3	62 95
A and D				0 80	1	3	12	183 68	1	1	4	9 5, 6 0	62 95
α Piscium	202	1 55 50	87 49 0	327 18	1	4	18	3 077	1	5	19		64 01
				325 77	3	16	113	3 237	3	20	110	4 4, 5 5	65 47
γ Andromedæ A and $\frac{B+C}{2}$	205	1 56 32	48 14 7	63 43	4	25	192	10 364	4	26	152		65 67
B and C	[38]			107 07	4	30	142	0 596	3	14	38	5 5 6 7	65 67
				101 34	1	4	16	0 6 est	1				72 67
ε Arietis	333	2 52 21	69 8 4	198 37	4	23	105	1 052	3	18	66	5 5, 6 0	66 69
52 Arietis	346	2 58 24	65 12 7	270 22	2	10	50	0 789	2	12	54	6 5 6 5	66 21
7 Tauri A and B	412	3 27 20	65 56 3	60 80	1	4	16	0 55 est	1			7, 7	64 93
A and C				61 45	1			22 869	1			7, 10 7	64 93
Camelopardi, P III 97		3 32 49	30 25 2	34 32	1	5	35	55 642	1	10	60	6, 9	63 02
ζ Persei A and B	464	3 46 35	58 28 4	207 26	2	10	22	14 160	2	10	15	3, 11	60 84
A and C				198 31	2	10	25	90 186	2	12	19	3, 10	60 84
A and D				185 16	2	9	22	121 532	2	10	20	3, 9 8	60 84
A and E				290 06	2	10	20	33 818	2	10	20	3, 12 2	60 84
40 Eridani o^2	518	4 9 49	97 48 7	106 97	1	3	27	80 772	1	4	32	5, 9 5	71 99
U Tauri (var ?)		4 14 49	70 28 2	202 10	2	6	19	3 101	1	4	8	9 9, 9 9	68 01
β Orionis (Rigel)	668	5 8 46	98 20 5	198 74	3	16	92	9 621	3	16	76	1 4, 8 5	66 00
η Orionis (D 5)		5 18 27	92 30 5	88 92	2	15	42	0 946	2	20	42		63 12
				88 41	1	5	30	1 080	1	4	10	4 5, 5 5	66 06
				89 83	1	8	36	1 021	1	6	24	4 3, 5 5	66 94
				89 26	1	4	25	1 038	1	4	20	4 5, 5 5	71 99

ψ² Orionis			5 20 33	87 0 6	322 30	2	15	34	2 843	2	20	40	5 5 11 2	63 16
					321 70	2	12	51	2 729	1	8	38	5 5, 11 0	65 10
52 Orionis		795	5 41 33	83 35 3	198 95	1	6	18	1 600	1	10	17		63 06
3 Monocerotis			5 56 12	100 36 1	356 13	1	3	15	1 797	1	4	16	10 0	72 14
4 Monocerotis	A and B		6 2 48	101 7 8	178 60	1	5	30	3 385	1	4	12	6 5, 10 5	72 14
	A and C				244 10	1	3	9	10 est	1			11 5	72 14
Lalande 12936			6 36 36	105 53 6	169 42	1	3	21	4 071	1	4	16	7 2, 9 5	72 14
α Canis Majoris (Sirius)			6 39 52	106 33 2	77 16	2	10	32	10 433	1	4	10	10 0	66 08
Geminorum ℍ V 66			7 20 30	67 36 1	276 72	2	10	80	35 971	2	12	73	7 6, 9 3	64 94
Neb ℍ IV 45			7 22 6	68 50 9	2 44	4	21	165	100 164	5	26	128	8 6, 7 5	64 98
α Geminorum (Castor)		1110	7 26 57	57 50 9	239 91	3	22	166	5 442	3	22	153	3, 3 5	64 93
					239 64	2	14	115	5 649	2	10	80	2 9, 3 5	65 96
					236 82	2	8	72	5 729	2	8	72		72 01
Argûs (Lalande 15219)			7 42 18	105 43 1	310 68	3	29	230	128 76	3	30	218	6 4, 6 5	64 22
ζ Cancri	A and B	1196	8 5 20	71 59 4	268 12	1	10	42	0 696	1	10	29		63 13
					240 82	3	22	92	0 638	1	4	14		65 36
					234 03	4	30	152	0 791	4	30	144		66 26
					228 29	1	6	34	0 659	1	6	30		66 94
					166 76	2	9	59	0 6 est	2				72 11
	A and C				143 96	1	8	46	5 236	1	10	47		63 13
θ Cancri			8 24 45	71 30 0	59 30	1	5	15	58 407	1	4	8	11 5	62 31
Cancri P VIII 129		1254	8 33 29	69 54 5	54 20	1	10	27					7 0, 9 7	62 17
Ursæ Majoris		1387	9 45 11	20 29 4	271 52	2	8	21	9 045	1	7	13	10, 10	64 03
Ursæ Majoris		1386	9 45 11	20 32 1	295 76	1	5	16	1 608	1	10	22	8 5, 8 5	64 04
γ Leonis		1424	10 13 21	69 33 1	110 49	3	16	129	3 212	3	16	121	3, 4	66 21
					112 73	3	15	107	3 033	3	12	72	2 4, 4 0	71 38
R Crateris (Var)			10 54 40	107 40 8	268 47	3	17	124	65 989	3	20	100	8 3, 9 8	66 36
ξ Ursæ Majoris		1523	11 11 48	57 47 4	29 66	3	10	100	1 086	3	14	78	4 8, 4 8	72 08
					16 80	3	16	101	1 110	3	12	72		72 44
ν Ursæ Majoris		1524	11 12 0	56 15 1	144 70	3	15	125	7 213	3	12	84	4 3, 10 3	72 08
β Leonis	A and B		11 42 56	74 54 4	206 36	2	7	63	282 420	2	7	49	8 4	64 40
	A and C				186 80	1	2	14	690 ±	1			10 0	64 37

H II 21 . B and C				77 05	1	4	14	61·105	1	4	8	8 5, 11	65 40
11 Scorpii		16 0 57	102 25 2	258 20	1	4	25	3 750	1	4	20	10 3	72 55
σ Coronæ Borealis	2032	16 10 12	55 50 1	194 39	3	12	77	2 973	3	12	68		67 34
				195 34	4	19	160	3 228	4	16	116		71 53
α Scorpii (Antares) ...		16 22 3	116 9 8	275 71	4	27	135	3 373	4	26	92	1, 7 6	64 44
ζ Herculis .	2084	16 36 47	58 10 9	206 53	4	21	106	0 992	4	16	66	3, 6 5	68 48
				183 34	5	26	156	1 021	4	16	92		71 54
Herculis	2120	17 0 0	61 44 6	263 33	3	14	87	3 866	3	12	66	7, 10	71 51
δ Herculis	3127	17 10 6	65 1 0	179 61	2	15	124	20 193	2	12	78	3 9, 8 5	66 74
				180 27	3	15	125	19 332	3	12	100	8 5	71 60
68 Herculis	[328]	17 12 54	56 46 2	62 46	2	12	83	4 312	2	8	52	4 8, 11 3	68 47
Herculis P XVIII 163	2190	17 30 52	68 55 6	23 36	4	4	32	9 632	1	2	16	6, 9 5	72 40
μ Herculis . . A and $\frac{B+C}{2}$	2220	17 41 47	62 12 1	243 87	2	9	75	31 324	2	10	66	4, 10 1	65 43
B and C				79 65	2	11	44	1 838	1	6	12	10 6, 10 7	65 43
95 Herculis	2264	17 56 25	68 24 1	260 34	2	10	83	6 366	2	8	56	5 3, 5 5	67 39
τ Ophiuchi	2262	17 56 33	98 10 7	246 86	4	35	114	1 200	4	38	92	5 4, 5 9	63 57
70 (*p*) Ophiuchi	2272	17 59 23	87 27 7	99 81	2	10	80	5 220	2	8	56	4 5, 7	67 44
				98 50	2	10	85	4 978	2	8	64	4 5, 6	68 56
				94 91	3	13	107	4 301	3	12	92		71 59
40 Draconis ..	2308	18 9 1	10 1 1	234 76	1	4	35	20 377	1	4	32	5 5, 6	65 84
α Lyræ		18 32 53	51 19 6	151 91	2	9	53	45 815	2	8	32	1, 10	65 80
θ Serpentis	2417	18 50 15	85 57 1	103 68	1	4	32	22 009	1	4	28	4 5, 5	65 84
Lyræ 91 B (B A.C 6468)		18 50 29	56 11 0	350 19	1	6	54	45 570	1	4	36	6 7 3	65 76
Lyræ P XIX 13 A and B	2472	19 4 24	52 16 8	337 61	1	3	24	18 478	1	2	14	8 3 10 2	68 52
A and C				348 58	1	2	18	76 747	1	2	8		68 52
C and D	2473			294 00	1	3	19	7 012	1	4	18	9 5 9 5	68 52
β Cygni . .		19 25 53	62 17 5	55 81	2	9	81	35 332	2	8	72		71 75
H I 13	2545	19 32 8	100 25 6	317 62	2	10	50	3 684	2	14	49	7 4 8 8	62 77
δ Cygni	2579	19 41 13	45 9 7	349 20	2	17	112	1 705	2	18	85	3, 8 4	65 43
				348 31	2	14	43	1 701	2	12	37	3 5 8 0	66 68
				337 92	4	20	124	1 590	4	16	80	8 9	71 74
				[illegible] 24	1	[illegible]	[illegible]	1 [illegible]2	1	4	20		[illegible]

Ḫ II 21	B and C				77 05	1	4	14	61 105	1	4	8	8 5, 11	65 40
11 Scorpii			16 0 57	102 25 2	258 20	1	4	25	3 750	1	4	20	10 3	72 55
σ Coronæ Borealis		2032	16 10 12	55 50 1	194 39	3	12	77	2 973	3	12	68		67 34
					195 34	4	19	160	3 228	4	16	116		71 53
α Scorpii (Antares)			16 22 3	116 9 8	275 71	4	27	135	3 373	4	26	92	1, 7 6	64 44
ζ Herculis		2084	16 36 47	58 10 9	206 53	4	21	106	0 992	4	16	66	3, 6 5	68 48
					183 34	5	26	156	1 021	4	16	92		71 54
Herculis		2120	17 0 0	61 44 6	263 33	3	14	87	3 866	3	12	66	7, 10	71 51
δ Herculis		3127	17 10 6	65 1 0	179 61	2	15	124	20 193	2	12	78	3 9, 8 5	66 74
					180 27	3	15	125	19 332	3	12	100	8 5	71 60
68 Herculis		[328]	17 12 54	56 46 2	62 46	2	12	83	4 312	2	8	52	4 8, 11 3	68 47
Herculis P XVIII 163		2190	17 30 52	68 55 6	23 36	4	4	32	9 632	1	2	16	6, 9 5	72 40
μ Herculis	A and $\frac{B+C}{2}$	2220	17 41 47	62 12 1	243 87	2	9	75	31 324	2	10	66	4, 10 1	65 43
	B and C				79 65	2	11	44	1 838	1	6	12	10 6, 10 7	65 43
95 Herculis		2264	17 56 25	68 24 1	260 34	2	10	83	6 366	2	8	56	5 3, 5 5	67 39
τ Ophiuchi		2262	17 56 33	98 10 7	246 86	4	35	114	1 200	4	38	92	5 4, 5 9	63 57
70 (*p*) Ophiuchi		2272	17 59 23	87 27 7	99 81	2	10	80	5 220	2	8	56	4 5, 7	67 44
					98 50	2	10	85	4 978	2	8	64	4 5, 6	68 56
					94 91	3	13	107	4 301	3	12	92		71 59
40 Draconis		2308	18 9 1	10 1 1	234 76	1	4	35	20 377	1	4	32	5 5, 6	65 84
α Lyræ			18 32 53	51 19 6	151 91	2	9	53	45 815	2	8	32	1, 10	65 80
θ Serpentis		2417	18 50 15	85 57 1	103 68	1	4	32	22 009	1	4	28	4 5, 5	65 84
Lyræ 91 B (B A C 6468)			18 50 29	56 11 0	350 19	1	6	54	45 570	1	4	36	6, 7 3	65 76
Lyræ P XIX 13	A and B	2472	19 4 24	52 16 8	337 61	1	3	24	18 478	1	2	14	8 3, 10 2	68 52
	A and C				348 58	1	2	18	76 747	1	2	8		68 52
	C and D	2473			294 00	1	3	19	7 012	1	4	18	9 5, 9 5	68 52
β Cygni			19 25 53	62 17 5	55 81	2	9	81	35 332	2	8	72		71 75
Ḫ I 13		2545	19 32 8	100 25 6	317 62	2	10	50	3 684	2	14	49	7 4, 8 8	62 77
δ Cygni		2579	19 41 13	45 9 7	349 00	2	17	112	1 705	2	18	85	3, 8 4	65 43
					348 31	2	14	43	1 701	2	12	37	3 5, 8 6	66 68
					337 92	4	20	104	1 690	4	16	80	8 9	71 74
					330 24	1	6	30	1 692	1	4	20		72 67

Name of Star	Σ Struve's No	R.A. 1880	N.P.D. 1880	Position	Nights	Obs.	Weight	Distance	Nights	Obs.	[illegible]	[illegible]	[illegible]
		h m s	° ′	°				″					
π Aquilæ	2583	19 43 3	78 25.8	121.21	4	26	130	1.451	4	25	124	6 6.3	65.67
P XX 25	2644	20 6 25	89 29.4	211.24	3	20	155	3.420	3	24	151	7.2 7.2	65.44
π Capricorni		20 20 27	108 36.2	144.92	3	18	95	3.154	2	8	40	6 10.3	71.70
ρ Capricorni		20 22 1	108 12.5	174.20	1	6	40	3.412	1	9	30	5 8.3	71.81
[illegible]	2725	20 40 37	74 32.0	357.65	2	14	84	5.025	2	12	60	7.3 8.0	65.77
γ Delphini	2727	20 41 6	74 18.3	272.74	1	5	44	11.732	1	4	32	4 5	65.78
[illegible] P XX 375	2735	20 49 40	85 55.5	285.64	3	21	124	2.110	3	18	81	6.5 [illegible]	65.74
ε Equulei A and B	2737	20 53 5	85 39.9	287.11	2	15	43	1.017	2	20	44	6 6.3	63.[illegible]
				290.47	2	20	127	1.113	2	20	94	6 6.2	64.74
				288.08	5	30	180	1.075	4	22	109	6.0 6.3	65.70
A and C				75.58	1	3	18	10.397	1	5	25	6 8	63.[illegible]
A + B / 2 and C				77.24	2	12	87	11.113	2	14	70	8	64.71
A and C				75.80	3	11	88	10.583	3	12	62	6.1 7.8	65.[illegible]
[illegible]	2742	[illegible] 5 18	83 17.4	224.5	2	13	84	[illegible]	2	11	[illegible]	[illegible]	[illegible]
61 Cygni	2758	21 1 33	51 52.4	111.[illegible]	2	10	60	[illegible]	2	12		5.5 6.1	[illegible]
				113.44	3	14	[illegible]	[illegible]	3	12	[illegible]		[illegible]
				114.45	2	12	84	[illegible]	2	1	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	80 21.[illegible]	[illegible]	2	11	53	2.131	2	[illegible]	24	[illegible]	[illegible]
				[illegible]	1	5	15	[illegible]	1	4	12	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	12	75	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	24	[illegible]	1	4	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	22	[illegible]	[illegible]	[illegible]	22	[illegible]	[illegible]	[illegible]
				[illegible]	2	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]

Name of Star	Struve's, No.	R.A. 1880	N.P.D. 1880	Position	Nights	Obs.	Weight	Distance	Nights	Obs.	Weight	Mags.	Epoch 1800+
π Aquilae	2583	19 43 3	78 25.8	121.21	4	26	139	1.451	4	28	124	6 6.3	65.67
P XX 26	[illegible]	20 6 28	89 29.4	211.24	3	20	155	3.400	3	24	151	7.2 7.2	65.44
π Capricorni		20 20 27	108 36.2	144.[illegible]2	3	18	95	3.154	2	8	40	6 10.3	71.79
ρ Capricorni		20 22 1	108 12.5	174.20	1	6	48	3.412	1	6	35	5 8.3	71.81
[illegible]	2725	20 40 37	74 32.0	357.05	2	14	84	5.035	2	12	[illegible]	7.3 8.0	65.77
γ Delphini	2727	20 41 0	74 18.3	272.74	1	5	44	11.732	1	4	32	4 5	65.78
[illegible] P. XX 375	2735	20 [illegible] 45	85 55.5	[illegible].24	3	21	124	2.[illegible]10	3	15	81	[illegible]	65.74
ε Equulei [illegible]	2737	22 53 5	[illegible]	[illegible].11	2	15	45	1.017	2	20	[illegible]	[illegible]	[illegible]
				[illegible]	2	20	127	1.11[illegible]	2	20	[illegible]	6 6.2	64.74
				[illegible]	5	30	180	1.075	4	22	109	6.2 6.3	65.70
A [illegible]				[illegible]	1	3	18	10.3[illegible]	1	5	25	[illegible]	[illegible]
[illegible]				[illegible]	2	12	8[illegible]	11.113	2	14	[illegible]	[illegible]	[illegible]
[illegible]				[illegible]	3	11	[illegible]	[illegible]	3	12	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	13	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	10	[illegible]	[illegible]	2	[illegible]		[illegible]	[illegible]
				[illegible]	3	14	[illegible]	[illegible]	3	12	[illegible]		[illegible]
				[illegible]	2	12	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	[illegible]	[illegible]	2	11	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	1	5	15	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	12	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	2		[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	5	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]			[illegible]	[illegible]		[illegible]	[illegible]			[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Name of star		Struve's [O Struve's] No	P A 1880	N P D 1880	Position	Nights	Obs	Weight	Distance	Nights	Obs	Weight	Mags	Epoch 1800+
			h m s	° ′	°				″					
π Aquilæ		2583	19 43 3	78 28 8	121 21	4	26	139	1 451	4	28	124	6, 6 3	65 67
P XX 26		2644	20 6 28	89 29 4	211 24	3	20	155	3 400	3	24	151	7 2, 7 2	65 44
π Capricorni			20 20 27	108 36 2	144 92	3	18	95	3 154	2	8	40	6, 10 3	71 79
ρ Capricorni			20 22 1	108 12 5	174 26	1	6	48	3 412	1	6	36	5 8 3	71 81
Delphini H II 66		2725	20 40 37	74 32 0	357 65	2	14	84	5 085	2	12	60	7 3, 8 0	65 77
γ Delphini		2727	20 41 6	74 18 3	272 74	1	5	44	11 732	1	4	32	4 5	65 78
Equulei P XX 376		2735	20 49 40	85 55 5	286 64	3	21	124	2 110	3	18	81	6 5 8	65 74
ε Equulei	A and B	2737	20 53 5	86 9 9	287 11	2	15	43	1 017	2	20	44	6 6 3	63 66
					290 47	2	20	127	1 116	2	20	94	6 6 2	64 74
					288 08	5	30	180	1 075	4	22	109	6 0 6 3	65 70
	A and C				75 58	1	3	18	10 387	1	5	25	6 8	63 60
	$\frac{A+B}{2}$ and C	..			77 64	2	12	89	11 113	2	14	76	8	64 74
	A and C				75 80	3	11	88	10 583	3	12	82	6 1 7 8	65 67
2 (ε) Equulei		2742	20 56 18	83 17 4	224 65	2	13	84	2 596	2	14	63	6 5 6 7	65 72
61 Cygni		2758	21 1 31	51 50 4	111 69	2	10	90	18 763	2	12	96	5 5 6 1	6[illegible] 72
					113 44	3	14	126	19 167	3	12	108		71 60
					114 45	2	12	84	19 603	2	10	64	5 5 6	73 00
γ Equulei		.	21 4 30	80 21 0	27[illegible] 34	2	11	53	2 131	2	8	24	4 7 11	67 54
					277 [illegible]	1	5	15	1 875	1	4	12	11	71 61
[illegible]		2777	21 [illegible] 38	80 2[illegible] 5	27 53	2	12	78	34 466	2	14	6[illegible]	4 5 10 3	[illegible]
1 [illegible] 23		[illegible]	21 2[illegible]	[illegible]	325 [illegible]	2	8	64	2 5[illegible]	2	1[illegible]	80	7 5 [illegible]	[illegible]
κ [illegible]		[illegible]	21 3[illegible]	[illegible] 54 4	[illegible]	1	5	20	11 9[illegible]	1	3	[illegible]	10 3	[illegible]
ζ Aquarii		[illegible]	22 22 [illegible]	[illegible]	[illegible]	3	17	110	3 [illegible] 44	3	1[illegible]	[illegible]	[illegible] 4 5	[illegible]
					333 1	3	15	130	3 348	3	12	1[illegible]		[illegible]
[illegible]		[illegible]	23 4 5	15 15 [illegible]	[illegible]	2	12	24	1 153	1	4	[illegible]	[illegible]	[illegible]
[illegible]		[illegible]	23 [illegible]	[illegible]	[illegible] 55	1	6	15	3 574	1	6	[illegible]	[illegible]	[illegible]
[illegible] H I [illegible]		[illegible]	23 [illegible] 27	[illegible]	[illegible]	1	6	15	1 4[illegible]	1	1[illegible]	2[illegible]	[illegible]	[illegible]
					[illegible]	3	22	125	1 432	3	22	1[illegible]2	[illegible]	[illegible]
					[illegible]	2	8	52	1 352	2	[illegible]	4[illegible]	[illegible]	[illegible]

III —*Second Catalogue of Micrometrical Measures of Double Stars, made at the Temple Observatory.*

By J. M. Wilson, M A , and G. M Seabroke, Esq

H. C. Schiel's Number	Name of Star	Struve's or other Number	Mags.	R A 1875	Dec 1875	Position Angle	No of Obs	Distance	No of Obs	Date 1870+	Observers	Remarks
				h m	° ′	°		′				
48	318 B Cephei	13	6, 6½	0 8 9	76 17	103 6 ±	9	0 52 ±	2	2 52	W S	Two nights, binary
58		16	7, 8½	9 8	53 57	39 8	5			6 93	W S	Measures bad, seems stationary
62		19	7, 9½	10 4	35 56	138 6	6	1 92	2	91	W S	Night hazy, seems stationary
66		23	8, 10	10 9	− 0 22	352 8	8	6 96	4	95	W S Sm	Rectilinear motion
127	49 B Cassiopeiæ	30	7, 8½	20 4	49 20	299 3	4	18 72	2	93	W S	Slow change
157		33	8 8 3	24 7	33 24	206 3	5	2 72	2	91	W S	Seems stationary
162	λ Cassiopeiæ	[12]	5 6, 5 9	24 9	53 50	140 7	7	0 5	est	5 92	W S	Movement, two nights
215		44	8, 9	31 6	40 18	265 4	8	8 84	2	6 95	W S	Motion very slow
319	36 Andromedæ	73	6 2, 6 8	48 2	22 57	356 0	6	1 38	2	4 94	S	Definition good, a binary
						358 6	4	1 28	2	6 95	W S	
344	P o 251	80	7, 8 2	53 0	0 7	312 9	6	20 31	5	4 73	W S	Slow motion, probably rectilinear, deserves attention
						313 7	3			6 95	S Sm	
373		86	8, 8 7	58 6	− 6 7	161 6	15	12 5	5	53	W S Sm	Two nights, slow motion
393	160 B Ceti	91	6 7, 7 5	1 0 8	− 2 24	322 2	5	3 81	4	4 93	W S	Slow motion, perhaps binary
439		101	7 5, 9 8	7 5	− 8 18	340 8	3	22 52	2	93	W S	Slow movement
474	42 Ceti	113	6 2, 7 2	13 5	− 1 9	348 0	8	1 45	2	93	W S Sm	Motion slow, but certain
515		125	8, 10	20 5	− 0 48	354 8	3	30 8	1	95	W	Rectilinear motion, rapid change.
568	P I 123 AB	138	6 2, 7 2, 8 5	29 5	6 59	352 7	4	30 34	3	6 95	W S	
						30 2	4	1 60	3	4 95	W S	Some change in angle
	AC					70 7	4	77 31	2	95	W S	
588		142	8 2, 8 4	32 9	14 37	327 6	6	17 72	2	6 95	W S Sm	Rapid rectilinear motion
650		162	7, 8	41 6	47 17	218 4	4	1 92	2	94	S	Very slow motion

Herschel's Number	Name of Star	Struve's or other Number	Mags	R A 1875	Dec 1875	Position Angle	No of Obs	Distance	No of Obs	Date 1870+	Observers	Remarks
				h m	° ′	°		″				
677		175	8 2, 8 5	1 44 2	20 30	343 2	6	14 62	2	6 94	S Sm	Decided motion, rectilinear
753	α Piscium	202	4 6	55 5	2 9	325 0	4	3 11	2	3 01	S	Decided motion
755	γ Andromedæ	[38]	8½, 9	56 3	41 44	105 7	6			6 79	W S Sm	Not divided clearly, a binary
1036	114 B Arietis	305	7 8	2 40 3	18 52	320 1	4	2 83	2	7 09	W S	Slow motion
1098	ε Arietis	333	5, 6	52 2	20 49	201 2	7	1 23	2	5 09	W S	Change in angle and distance, [deserves attention
						200 7	6	1 36	2	7 09	W S	
1179		367	8, 8	3 7 8	0 20	246 7	6	0 73	2	2 51	W S	Two nights, binary.
1207		375	7 9	13 0	23 15	316 0	4	2 30	2	7 09	S	Stationary
1222		380	9, 10	15 1	8 17	70 1	4			09	W S	Certain motion
1308	P III 98	422	6 2, 8	30 8	0 12	242 0	7	6 41	3	09	W S	Certain motion
1318		425	7, 7	32 2	33 44	98 9	4	2 52	2	09	W S	Very slow change
						99 5	4	2 44	2	15	W S	
						99 3	4	2 61	2	16	W S	
1338		434	7, 7 8	35 8	37 59	87 0	4	30 23	2	15	W S	Distance increasing slowly
						87 4	4	30 22	2	16	W S	
1406	49 Hev Cephei	460	5½, 6½	49 3	80 21	25 1	5	0 86	3	2 10	W S	A binary
1506		494	7 7 1	4 0 5	22 45	187 2	4	5 78	4	7 15	W S	Very slow change
						187 6	5	5 55	2	16	W S	
1517		504	8½ 10	6 0	67 16	265 0	4	6 70	2	5 18	S	Stationary
1523		506	9 9	7 7	70 7	292 5	5	7 15	1	18	S & A M W	Very slow change
1526		510	7, 9 5	5 7	0 26	299 8	4	11 53	2	09	S	Stationary
1528		511	6 7	7 5	58 31					09	W S	Failed, a probable binary
1549		517	7, 9	9 7	0 10	12 8	6	3 52	3	4 18	W Sm	Stationary
						15 1	5	3 28	2	5 09	S Sm	
1560		521	7 10	12 1	49 42	257 3	10	2 33	3	09	W S Sm	Very slow
						257 1	5	1 78	2	7 09	W Sm	
1600	230 B Tauri	535	7, 8	16 4	11 4	339 7	9	1 66	5	3 13	W Sm	Two nights, orbital motion
						341 9	5			5 18	S	

						339 3	5	1 75	2	19	S	
						338 4	4	2 01	2	7 09	W S	
1626		546	8, 9	19 8	18 49	187 9	4	7 03	2	09	W	Observation unsatisfactory star [stationary
1631		547	8 5, 11 5	19 7	− 1 41				...	4 08	S	Failed.
1636	1 Camelopardi	550	5, 6	22 3	53 38	307 4	4	10 42	4	5 09	W S & L	Stationary.
						308 0	3	10 37	2	18	S & A M W	
1648	80 Tauri	554	6½, 9½	23 1	15 23	14 7	6	1 29	2	4 07	S	Three nights, uncertain, change [slow
1687	2 Camelopardi	566	5, 8	29 9	53 15	294 3	5	1 54	2	5 09	W S Sm	Not good definition, binary
1703	4 B Aurigæ	572	6, 6½	30 6	26 40	205 6	4	3 65	2	09	S Sm	Slow motion
1715		577	7½, 8	33 8	37 15	84 7	10	1 47	1	2 16	W S	Certain motion
						82 1	3	1 24	2	5'09	S Sm	
						82 5	6	1 36	1	18	S	Very bad night
1720		579	8 5 11	34 4	22 29	36 0	2	15 56	1	09	S	Slow motion
						35 2	5	16 86	2	18	S Sm	
1726		583	8, 9	34 7	0 44	325 3	6	5 59	3	09	W S Sm	Very slow
1748		589	8, 8	38 1	5 4	122 5	6	4 30	2	09	W S	Very slow
1796		607	8 5, 11	45 5	25 13	254 6	2	13 74	2	09	W S	Slow motion
1845		620	8, 9	51 4	13 45	232 0	9	3 63	2	09	W S Sm	Slow motion
1871		629	8, 10	5 34	83 18	359 5	3	13 80	1	09	W L	Motion
1892	19 Hev Camelopardi	634	4, 7	2 1	79 4	0 1	3	21 30	2	09	W S L	Rectilinear motion
1925		644	6 7	1 9	37 9	220 5	4	1 60	2	09	W S	Stationary
						221 9	4	1 79	1	6 12	S	
1930		646	8 9	2 4	39 7	73 6	4	15 66	2	5 09	W S	Stationary
1947		651	8, 10	4 0	− 7 14	59 3	5	16 26	2	18	S Sm	Rapid change, an interesting [system
1961	14 Aurigæ AB	653	5, 6 5 11	7 3	32 33	226 1	4	15 08	3	09	W S Sm	Stationary
						227 3	3	15 09	2	18	W S	
						228 0	5			6 12	S Sm	
						226 3	4	14 94	2	7 15	W S	
						225 8	4	14 99	2	18	W Sm	
	AC					349 4	2	13	est	5 18	S	
						348 5	2	12	est	7 15	W S	
						348 3	3			18	W, Sm	
1963	ρ Orionis	654	4, 8	6 7	2 45	64 8	3	6 84	2	6 12	S	Stationary

Herschel's Number	Name of Star		Struve's or other Number	Mags	R A 1875	Dec 1875	Position Angle	No of Obs	Distance	No of Obs	Date 1870+	Observers	Remarks
					h m	° ′	°		″				
1983	Rigel		668	1, 7	5 58.6	−8 21	205.0	2			4.09	Sm	Slow motion
							204.4	4			6.12	S	
2017			684	8, 9½	13.3	44 57	141.0	4	1.33	2	5.09	W S	Very slow
2050			694	8, 8½	16.4	24 51	4.2	8	1.24	2	4.10	S Sm	Stationary, or very slow
2054	23 Orionis		696	5½, 8	16.1	3 24	29.4	3	32.43	1	10	S	Stationary
2103	118 Tauri		716	6½, 7½	21.6	25 3	201.8	5	5.01	2	5.18	S	Stationary, or very slow
							200.5	3	5.17	2	7.16	W S	
2127	31 Orionis		725	5.8, 11	23.2	−1 11	87.6	8	13.73	1	5.18	S Sm	Stationary
2129			727	8, 9.5	24.9	44 41	59.2	5	1.98	2	7.18	W S	Very slow
2133	32 Orionis		728	5½, 7	24.0	5 51	198.5	2			4.10	W S	Not divided, perhaps binary
2212	σ Orionis	AB	762	4, 7, 7, 10	32.5	−2 41	240.9	2	42.57	1	10	S	Stationary
							242.1	3	41.58	1	5.18	S	
							241.0	2			19	S	
		AC					84.1	2	13.19	1	4.10	S	
							86.7	4	11.91	2	5.18	S	
							85.2	2	12.09	1	19	S	
		AD					235.5	2	10.19	1	4.10	S	
							241.4	2			5.18	S	
							236.8	2	11.62	1	19	S	
2264			787	8 8½	38.4	21 18	77.0	7	1.12	2	09	W S Sm	Motion slow, if any
2384			826	8½, 9½	52.7	−1 19	131.0	4			18	S	Motion slow
							126.1	2	1.77	3	19	S	
2401		AB	830	8.2 8.7 10.8	55.6	27 39	254.8	4	12.09	2	7.18	W S	Very slow
		AC					189.5	3			18	W S	
2447	41 Aurigæ		845	6 7	6 2.0	48 44	355.0	4	7.83	2	4.15	Sm	Definition perfect (position probably in error), system stationary
2449			844	8 9	0.8	13 59	8.3	3	23.86	1	5.18	S	Slow change
							8.2	3	23.90	2	4.13	W S	15 stars in field, one close double
2450			S 507	9 9½	1.3	14 0	221.9	3			13	W	Stationary
2455			848	8 10	1.4	13 59	110.7	5	2.48	2	13	W	S 506 Stationary

							109 8	4	2 24	2	16	S	
2456			850	8, 10	1 2	− 3 58	14 2	6	1 62	1	14	S Sm	Stationary
2463			854	9, 10	2 1	5 48	321 1	3	5 33	1	13	S Sm	Stationary
							322 2	5	5 55	2	5 19	S Sm	
2465			856	8, 10½	2 2	7 5	49 0	6	0 25	2	4 13	W S	Distance a guess, very faint
							51 4	3	9 56	1	5 19	S Sm	Seems stationary
2477			860	8, 10	3 3	24 55	357 5	5	5 62	2	19	S	Stationary
2522			880	8, 8	8 5	10 37	57 1	5	5 58	2	19	S	Very slow
2647	229 B Aurigæ		918	7, 8	23 8	52 33	325 8	3	4 67	2	7 16	W S	Very slow, perhaps binary
							326 5	6	4 54	2	18	W S	
2667	20 Geminorum		924	6, 7	25 0	17 52	212 7	5	19 87	2	5 19	S	Slow motion
2718			942	9, 9 2	29 9	23 47	243 7	4	2 67	2	4 13	W S	Too faint for dist, seems stationary
2802	14 Lyncis		963	6, 6½	42 0	59 34	65 8	5	0 66	1	2 27	S	Clearly divided, some motion
2899	μ Canis Majoris		997	5, 8 5	50 2	−13 53	343 9	3	3 75	2	5 19	S Sm	Stationary
2907		AB	1001	7 1, 8 7	53 2	54 23	62 3	4	9 65	2	7 18	W S	C not measured, stationary
2952			1014	9, 9	58 3	26 21					4 19	S	Could not find it
3012			1037	7 1, 7 1	7 5 2	27 28	317 6	6	1 31	1	5 19	S	Decided motion, orbital
3066			1060	8, 9	10 3	− 9 3	25 1	4	7 63	2	6 22	S	Very slow
3084	δ Geminorum		1066	3 8	12 5	22 12	202 9	4	7 12	2	22	S	Slow motion
3107			1076	9, 9	14 5	4 18	110 0	4			22	S	Very slow motion, if any
3228	Castor		1110	2 7, 3 7	26 6	32 9	239 0	4			3 28	S	Barlow lens, 2nd power, definition satisfactory
							235 9	4			6 22	S	
							234 2	4			35	W Sm	Definition bad
3297	P VII 170		1126	7 7 7	33 4	5 32	139 9	4	1 59	1	22	S	Certain motion
3557	ζ Cancri	AB	1196	5, 5½ 7½	8 49	18 2	133 7	4	0 80	1	5 26	S	
							133 0	9	0 75	1	32	S Sm	Unsteady
		AC					131 5	4	5 72	1	26	S	
							131 7	4	5 53	2	27	S	
3572	P VIII 13		1202	8 10	6 9	11 14	328 2	9	1 9	2	2 28	S	A binary
							324 9	5	2 15	2	5 28	S	
3646			1216	7, 7½	14 6	− 1 11	166 2	3			27	S	Not separated, motion rapid in angle
							164 8	4			28	S	Unsteady, not separated
3832			1263	7, 7½	37 0	42 9	18 8	5	37 15	2	27	S.	Rapid motion, probably rectilinear

J C Herschel Number	Name of Star		Struve's or other Number	Mags	R A 1875	Dec 1875	Position Angle	No of Obs	Distance	No of Obs	Date 1870+	Observers	Remarks
					h m	° ′	°		″				
							19 5	4	37 50	2	5 27	S	
							20 4	7	37 50	2	32	S Sm	
3868	ε Hydræ		1273	4, 8	8 40 2	6 54	221 5	7	3 47	2	32	S	Binary
4021			1316	8, 11	9 1 5	− 6 39	162 8	4	5 15	1	6 26	S	Motion certain
4048			1322	8, 8	5 9	17 1	54 3	6	1 84	2	26	S	Stationary
4087	38 Lyncis		1334	4, 7	10 9	37 20	236 3	4	3 28	1	26	S	Distance probably in error,
							237 6	7			29	S Sm	[nearly stationary
4101	157 B Lyncis		1338	6 7, 7 2	13 0	38 43	150 0	4	1 73	2	5 27	S	Decided motion
							150 5	4	1 55	2	29	S	
							150 0	5	1 78	2	6 26	S	
4126	21 Ursæ Majoris		1346	7, 8	16 7	54 32	310 1	4	5 65	2	26	S	Stationary
4139	116 B Hydræ		1348	7½, 7½	17 8	6 51	324 3	4	1 80	2	26	S	Decided motion
							324 9	4			29	S	
4165	ω Leonis		1356	6½, 7¼	21 6	9 38					3 24	W	Not divided, closer than ζ *Cancri* or Σ 1216
							74 7	5	0 5	est	6 26	S Sm	
							72 3	4	0 6	est	29	S	Just divided
4170			1357	7, 10½	22 0	− 9 27	53 9	6			26	S Sm	Stationary
4253	P IX 161		1377	8, 11	36 9	3 12	141 3	4			26	S	Stationary
							144 2	5			29	S Sm	
4411	Regulus	AB	H & S 111	1 8 5	10 1 7	12 35	307 0	2			3 24	W	Stationary, agrees with South in 1824
		AC					269 8	1			24	W	
		BC					225 9	1			24	W	
4469	γ Leonis		1424	2 4	13 1	20 29	110 2	4	3 04	2	23	W	Readings hurried by visitors
							111 8	8			25	W H F	
							112 9	5			6 25	S Sm	
4477	145 B Leonis	AB	1426	7½ 8 9	13 9	7 4	278 3	2			26	S	Motion certain, very close
		AC					10 9	3	8 25	2	26	S	A triple system
							10 7	2	7 78	2	29	S	

4501		1429	8 6, 8 8	10 18 0	25 14	261 5	4	0 75	est	29	S Sm	Some change
4536		1439	8, 8½	23 4	21 26	122 3	2	1 96	1	5 27	S	Certain motion
						121 0	4	1 82	2	30	S	
4575	49 Leonis	1450	6½, 9	28 4	9 16	157 7	4			6 30	S	Very nearly stationary
						158 5	4			34	S Sm	
						160 6	4	2 48	2	35	S	
4606		1457	7 3, 7 8	32 2	6 21	316 1	4	1 26	2	5 28	S	Decided motion
						313 6	5	1 20	2	28	S	
						315 3	7	1 12	1	32	S	Difficult
						314 2	5	1 17	1	6 34	S	
4611	172 B Ursæ Majoris	1460	8 8	33 2	42 49	168 1	4	3 19	2	5 28	S	Stationary
4683	AB	1474	7 8, 8	41 5	—14 36	199 1	4	6 86	2	28	S	Some change probable
						197 7	4	6 56	2	29	S	
						199 1	4			6 34	S	
	AC					22 6	2	77 44	2	5 28	S	
						23 8	1			6 34	S	
4693		1476	7 5, 8 2	42 6	— 3 21	359 1	9	2 57	2	5 32	S Sm	Nearly stationary
4696		1478	8, 11	44 3	25 8	352 3	6			6 34	S	Very slow, if any motion
						350 3	3			35	S Sm	
4754		1500	7, 8	53 5	— 2 46	317 1	4	1 40	2	5 28	S	Motion
						316 9	7	1 27	2	29	S	
						315 6	5	1 34	1	6 34	S	
						316 2	5	1 31	2	36	W	
4782	P X 229	1504	7½, 7½	57 6	4 18	286 4	4	1 08	2	5 28	S	Certain motion
						285 5	4	1 12	1	29	S	
						286 7	4			6 34	S Sm	
4833		1516	7, 7 5	11 7 2	74 9	89 6	4	8 81	2	5 28	S	Binary
4834	P XI 9	1517	7 3, 7 3	6 6	20 50	105 1	4	0 82	2	28	S	
						106 0	4	0 75	est	6 34	S Sm	
4860	ξ Ursæ Majoris	1523	4 5	11 5	32 14	317 6	4	1 30	2	5 28	S	Binary
						316 9	5	1 22	2	29	S	
						318 0	5	1 31	2	32	S	
						316 3	10			43	S Sm	

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				h m	° ′	°		″				
						304 9	4	1 59	3	6 34	S Sm	
						306 4	9	1 45	2	36	W S	
						305 2	6	1 30	3	37	W S	
						294 1	6	1 47	3	7 39	W S	
						294 7	7	1 59	4	40	W S	
						295 0	7	1 50	2	41	W S	
4861	ν Ursæ Majoris	1524	4 10	11 11 8	33 46	149 2	3			6 34	S Sm	Stationary
						148 5	5			35	S	
4865	339 B Leonis	1527	7, 8	12 4	14 58	13 9	3	3 90	2	3 24	W S	Very slow
4870	P XI 39	1530	8½, 9	13 5	– 6 13	313 4	4	7 64	2	6 35	S	Stationary
4885		1534	8 11	15 4	18 55	334 5	3			35	S	Slow motion
4896	ι Leonis	1536	4 2, 8	17 3	11 13	68 5	4	2 77	2	5 28	S	Binary
						70 5	8	2 69	2	6 35	S Sm	
						70 2	6	2 62	2	36	W S	
	L 21697	B 26	7 11½	17 2	– 9 42	73 0	9	3	est	4 30	W S Sm	Very difficult, Burnham estimated at 75° and 2′, position [for 1870
4924	57 Ursæ Majoris	1543	6, 8	22 4	40 1	7 0	4	5 58	2	5 28	S	Slow motion
						6 4	4	5 62	1	6 35	S Sm	
4942		[235]	6 7 3	25 2	61 46	54 4	10	1 03	4	7 41	W S Sm	A binary
						55 7	12	1 16	2	45	W S Sm	
4970	90 Leonis AB	1552	7 8	28 1	17 30	212 2	5	3 52	2	3 34	W S	Nearly stationary
						211 5	6	3 42	2	5 32	S Sm	
						211 0	4	3 19	2	33	S	
4978	P XI 111	1555	6 7, 7	29 8	28 28	343 8	7	0 75	1	28	S	Very slow motion
						342 8	4	0 74	1	30	S	
						342 8	3	0 75	est	6 35	S Sm	
4981	AC	1558	9 9 9	31 1	22 12	277 2	3	44 00	2	5 29	S	Unsteady
						276 0	1			30	S	
						276 6	3			6 36	W S	

		AB					154 8	4	1	est	5 30	S	Nearly stationary
							153 5	6			6 36	W S	
5000			[237]	7 4, 9	32 3	41 50	271 0 ±	6	0 9	est	7 41	W S	Night bad
							275 2	7	1 16	2	45	W S	Motion somewhat doubtful
5093			1578	9, 11	47 0	4 22	163 6	6	2 5	est	36	S	Stationary
							170 8	5	3 65	1	38	W S	
5104			1580	8, 9	49 0	4 16	260 6	4	8 72	2	36	W S	Stationary
5148			1594	9, 10	57 1	42 5	161 6	5	12 65	1	5 30	S	[probable Almost a guess, some change
							160 7	5	14 07	1	6 36	S Sm	Distance estimated with wires
5153	2 Comæ		1596	6, 7½	57 9	22 10	239 5	3	3 90	4	36	W Sm	Stationary
5205			1607	8, 8½	12 5 1	36 47	357 2	6	30 77	3	48	W S	Apparently changing
	L 23106		B 27	7, 12	13 5	14 35	105 0	6	4	est	4 30	W S	Burnham estimates at 110° and 4″ in 1872, position for 1870
5319	191 B Virginis		1647	7, 7 6	24 2	10 25	217 2	5	1 28	2	5 29	S	Unsteady, some motion.
							216 9	4	1 08	1	30	S	
5334			1654	7, 8½	26 8	75 30	21 4	7	4 57	2	3 33	W S	Described by H & S as very difficult, they give 22 84 and 5 86
	BAC 4213		B 28	6½, 12, 10	23 4	−12 40					4 26	W	No close comp seen, night bad, distant companion at 290″ 8
							2 0	4	2 5	est	30	W S	R A $12^h 23^m 23^s$, Dec −12° 40′, Burn est at 355° & 3″ in 1872
·	L 23536		B 29	7, 13	29 0	−16 7	261 0	4	12'	est	24	W	Too faint for dist measures, position for 1870 R A Burnham est at 260° and 10″ in 1872
5354			1663	7 8, 8 7	31 0	21 53	112 4	6	0 7	1	5 29	S	
							109 8	3	0 7	est	6 36	W Sm	Difficult, nearly stationary
5358		AB	1664	8, 9, 11, 11	31 9	−10 48	252 0	4	20 61	2	5 36	S	Very uncertain results
							252 0	2			6 36	W S	An interesting quadruple
		AC					306 2	2			5 36	S	System probably in motion
							306 0	2			6 36	W S	
		AD					287 0	2			5 36	S	
							293 7	2			6 36	W S	
		BC					333 2	2			5 36	S	
							324 6	2			6 36	W S	
		CD					268 5	2			5 36	S	

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					h m	° ′	°		″				
5377	γ Virginis		1670	3 3	12 35 3	− 0 45	340 0	5	4 97	1	5 30	S	Binary
5427	359 B Virginis		1686	8, 8 2	46 7	15 43	187 6	6	5 43	3	6 36	W S	Stationary
5430	35 Comæ	AB	1687	5½ 8½, 8½	47 2	21 55	56 8	3	1 10	2	3 35	S	Very unsteady, binary
							57 7	4	1 40	1	5 30	S	
							58 4	7	1 27	2	32	S Sm	Very shaky
							61 1	7			39	S	
							56 2	5			43	S Sm	Bad night
							58 5	7	1 40	2	6 36	W Sm	
							67 1	3			36	S	
		AC					124 9	5	28 63	2	5 29	S	
							125 3	4	28 69	2	30	S	
5461			1699	7 8 7 8	52 6	28 12	1 3	7	1 43	2	6 38	W S	Stationary
5462			1700	8 2 10	52 7	27 46	84 1	4	6 94	1	38	W S Sm	Stationary
							85 6	8			41	W S	
.	P XII 243	AB	B 112	6½ 9, 10	54 8	19 1	347 3	1			4 30	W	Burnham estimates at 345° and 155″ and 290° and 2″ in 1873 Position for 1880
		BC					289 8	3	1 5	est	30	W Sm	BC difficult
							297 0	2			30	S	
5482			1709	7 1 9 9	56 3	24 9	247 8	6	2 18	2	6 38	W S	Fixed
5483			1711	8½ 9	56 8	14 9	352 3	8	1 13	2	41	W S	Stationary
5487			1712	9 9 4	57 3	10 8	333 0	5	9 19	1	5 29	S	Slow motion
5495	427 B Virginis	AB	1716	8 11 12	58 4	9 19	150 5	4	2 25	1	30	S	Stationary
		AC					234 0	2			30	S	
		AD					25 3	1			30	S	
5515	179 B Comæ		1722	8 9	13 2 1	16 10	339 2	4	3 39	2	30	S	Very slow motion
							340 6	5	3 37	2	31	S	
5523	42 Comæ		1728	5 5 5 7	4 0	18 12	192 5	1	0 5	est	30	S	Binary
							186 4	4	0 5	est	6 36	W Sm	

5535		[261]	6 9, 7 4	6 1	32 45	350 9	5	1 14	3	7 45	W S	Change in angle and distance
						348 4	6	1 22	2	46	W. Sm	
5570		1734	7, 8	14 5	3 35	195 6	6	1 10	2	5 30	S	Stationary
						194 1	8	1 01	2	35	S Sm	
						195 4	5			39	S	
5590		1742	7, 8	18 0	2 2	350 8	4	0 98	2	30	S	Stationary
5610		[266]	7 3, 7 8	22 3	16 23	336 2	5	1 27	2	7 45	W S	A binary
						336 1	6	1 22	2	46	W Sm	
5614		1747	8 2, 9 5	22 3	48 24	347 0	4	15 00	2	5 30	S	Stationary
						344 2	4	15 47	2	35	S	
						345 3	6			41	S	Very unsteady
		B 114	8, 8	28 0	− 8 0	133 5	5	1 38	2	4 30	W S	Burnham est at 1 30 and 1 8 in [1873, position for 1880
5639	P XIII 127	1757	8, 9	27 9	0 20	66 5	6	2 21	3	6 41	W S	Binary
						67 2	6	2 15	3	36	W S	
5642		1758	8 8	27 5	49 41	307 3	6	4 31	2	5 30	S	Slow
						307 4	4	3 70	2	35	S	
						307 9	5			41	S	Unsteady night
5662	81 Virginis	1763	7 5, 7 5	30 9	− 7 11	41 8	6	2 65	3	6 46	S Sm	Stationary
5704	84 Virginis	1777	6, 8	37 1	4 11	230 1	4	3 60	2	46	S Sm	Slow.
5726		1781	7 7 8	40 0	5 44	261 7	5	1 20	1	36	W S	Decided motion, orbital.
						262 5	6	1 20	1	45	S	
5754		1785	7, 7½	43 5	27 34	206 1	5	2 46	2	5 35	S	Binary
						207 9	7	2 58	1	39	S	
						206 7	5			41	S	
						208 4	6	2 28	3	6 41	W S	
						208 8	5	2 14	2	7 47	W	
5789	P XIII 238	1788	6 5, 8	48 3	− 7 27	75 4	6	2 55	3	2 38	W S	Decided motion, orbital
5862		S 660	8½ 10	14 2 3	21 49	19 6	4	4 73	2	6 41	W S	Stationary, S gives 20° 3 and 4″ 88 in 1826
5878		1806	9 10	3 9	49 7	172 7	8	13 42	4	5 35	S Sm	Stationary
						171 2	8	13 00	2	41	S	Unsteady night
5881		1807	8, 8	4 7	− 2 43	27 8	7	7 19	2	6 41	W S	Stationary
5907		1819	8, 8	9 3	3 43	22 2	4	1 40	1	5 35	S Sm	Binary

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				h m	° ′	°		″				
						26.5	3			5.39	S	
						23.6	7			41	S	
						23.2	5	1.37	1	6.41	W S	
5912	κ Boötis	1821	5 7	14 8.9	52 23	242.8	6	12.99	3	46	W S	Very slow
5934		1832	9, 9	12.9	4 28	120.5	2	0.4	est	46	S Sm	Too close for good measures, stationary
5937		1831	6.3, 9	12.2	57 17	141.2	3	6.5	2	3.25	W S	Stationary
						140.3	4	5.6	2	30	S	
5952	P XIV 62	1833	7, 7	16.0	− 7 11	169.6	4	5.71	2	6.41	W S	Stationary
5961	P IV 69	1835	6 8	17.2	8 59	188.9	5	6.42	2	41	W S	Stationary
5993	φ Virginis	1846	5, 10	21.9	− 1 39	111.2	5	4.20	2	5.41	S Sm	Very slow
						114.6	7	4.33	2	43	S Sm	
						111.9	8			44	S Sm	
6040		1858	7.2, 8	28.6	36 6	34.6	4	2.53	2	6.38	S Sm	Stationary
6066	π Boötis	1864	3½, 6	34.8	16 58	101.5	6			2.38	W S	Stationary
						100.8	4	5.90	2	3.36	W S	
						101.3	6	6.11	3	37	W S	
						102.2	7	5.96	2	4.41		
						102.5	2	5.86	3	42	W G	
						103.7	4	5.91	3	7.46	W	
						103.0	2	6.22	1	46	Sm	
						102.5	8	5.95	4	47	W Sm	
6072		1866	8, 8	35.7	10 3	22.9	6	0.77	2	5.41	S Sm	Stationary
6073	260 B Boötis	1867	7.7, 8.2	35.4	31 49	14.1	4	0.97	4	6.46	W S	Some motion
6099		1876	8 8.6	39.9	− 6 51	56.0	2			4.42	Sm	Very difficult and misty, motion small
6101	ε Boötis	1877	3, 7	39.5	27 36	327.1	6	3.19	1	5.39	S	Distance probably in error, some motion
	μ Libræ	B 106	5 7	42.2	−13 36	345.0	5	1.54	2	4.29	W S	Very unsteady and difficult Burnham estimates at 340° and 1″.3 in 1873, position given for 1870

6146	ξ Bootis	1888	4 7, 6 6	45 5	19 37	283 0	5	4 46	5	7 46	W Sm	A binary
6161		[288]	6 4, 7 1	47 5	16 14	195 8	9	1 49	4	45	W S	A binary
						195 8	6	1 31	2	46	W Sm	
6245	P XIV 279	1910	7, 7	15 1 5	9 42	210 9	4	4 66	2	5 39	S	Stationary
						211 2	9	4 16	3	41	S Sm	
						211 8	6	4 35	2	43	S Sm	
6331	1 B Coronæ	1932	6, 6½	13 0	27 19	300 2	5	1 29	1	39	S Sm	Binary
						301 5	6	1 07	4	7 47	W S	
6336		1934	8 5, 8 5	13 1	44 17	36 3	4	6 30	2	43	S	Decided motion, orbital
						35 3	5	6 33	1	44	S Sm	
6362	η Coronæ Borealis	1937	6, 6½	18 1	30 45	66 7	6	0 94	2	30	S	Binary
						68 0	7			32	S	
						66 6	5			32	Sm	
						68 7	6			32	S	
						68 8	8			43	S Sm	
						82 9	9			47	W S	
6371	μ_2 Bootis, P XV. 74	1938	8, 8 5	19 8	37 45	143 5	8			43	S Sm	Bad definition, a binary
						147 6	9	0 7	est	44	S Sm	
						144 6	7	0 84	1	52	S Sm	
						150 6	7			59	S	
6382		1944	7½, 8	21 7	6 31	140 4	13	0 65	2	45	W Sm	Neatly in contact, two nights
						335 0	7	1 15	2	5 42	S Sm	Very slow
6388		[296]	7½, 9	22 0	44 28	334 7	7	1 03	1	49	S Sm	
						315 9	5	1 40	1	49	S Sm	Probable binary
6406	17 B Coronæ	1950	7, 8	24 7	25 57	315 5	5	1 34	3	7 45	W	Difficult, definition bad
6426	δ Serpentis	1954	3 5	28 7	10 57	91 8	4	3 28	2	5 44	S	Stationary, or very slow
6434		1957	8, 9½	29 9	13 19	190 0	8	3 41	2	51	S Sm	Binary
						161 2	7	1 40	1	50	S	Stationary, or very slow
						161 8	7			51	S Sm	
						156 6	5	1 5	est	6 48	W S	
6446	AB	[298]	7, 7 3, 7	31 5	40 14	234 0	5			3 40	W Sm	Rev H E Lowe seems to have made it 188°, and clearly separated, in 1868, probably in rapid motion as a binary

Herschel's Number	Name of Star	Struve's or other Number	Mags	R A 1875	Dec 1875	Position Angle	No of Obs	Distance	No of Obs	Date 1870+	Observers	Remarks
				h m	° ′	°		″				
	AC					232 0	3	0 45	est	3 48	W	
						328 4	1			40	W	
						327 8	1			48	W	
6535		1985	7 8	15 49 6	− 1 47	334 6	5	6 10	2	6 46	S Sm	Distance probably in error, slow motion
6544		1988	7 5 8 2	51 0	12 50	262 3	3	3 04	2	38	W S	Unsatisfactory obs, stationary
6582	51 Libræ AB	1998	4½, 5	57 4	−11 2	180 0	6	1 33	2	5 51	S Sm	Binary
						184 9	8	1 27	3	7 46	W Sm	Distances by W
	AC					73 4	7	6 38	3	46	W Sm	
6610	κ Herculis	2010	5 6	16 2 3	17 23	10 4	3	30 75	1	6 46	S Sm	Very slow
6634	49 Serpentis	2021	7 7½	7 5	13 51	329 4	6	3 44	2	5 51	S Sm	Binary
						327 0	6	3 56	3	6 48	W S	
6645		2026	9 9	8 7	7 41	321 3	8	1 40	1	5 51	S	Decided motion, binary
						320 8	5			51	S	Very bad night
6654	σ Coronæ Borealis AB	2032	5 6½ 11	9 7	34 12	200 6	5	3 47	2	50	S Sm	Binary
						202 2	6	3 68	2	7 46	W Sm	
	AC					88 3	5			5 50	S Sm	
						87 4	2	54 18	1	7 46	W	
6661	υ Coronæ Borealis AB		6 10, 9 13	11 7	29 28	23 3	4			5 50	S	These measures do not agree very well with Smyth's in the Bedford Catalogue
						23 0	2			51	S	
	AC					53 3	2			50	S	
						52 8	2			51	S	
	AD					19 2	3			50	S	
	CB					275 1	2			51	S	
	BD					227 0	3			50	S	
						227 3	4			51	S	
6716		[311]	7 5, 10 3	22 4	21 11	188 7	3	7 80	2	7 45	W	Remarkable diminution of distance
						189 2	4	8 20	2	46	W Sm	
6721		2051	7 8½	23 5	10 51	20 8	4	13 87	2	5 51	S	Stationary or very slow

6722	71 B Herculis		2052	7½, 7½	23 6	18 42	21 1	4	13 89	2	52	S Sm	
							101 6	6			4 54	W F	Slow motion
							103 0	4	2 76	2	5 51	S Sm	
6727	λ Ophiuchi		2055	4, 6	24 6	2 15	33 4	6	1 54	2	52	S Sm	Binary
6775			2072	8½, 9½	32 0	47 56	181 8	6	4 24	2	52	S Sm	Very slow
6784			2076	9, 10	34 3	0 6	328 0	4	9 32	2	56	S	Stationary
							328 0	5	9 37	2	57	S	
			B 42	9, 10	35 0	29 16	39 4	5	6 80	2	4 43	W	Position for 1870, Burnham est at 35° and 4″ in 1872
6799	ζ Herculis		2084	3 6½	36 7	31 49	149 4	5			5 57	S	Very bad night, a binary
							151 2	5			58	S	
6821	46 Herculis		2095	7, 9	40 0	28 34	166 4	5	5 08	2	56	S	Stationary, or very slow
6822	19 Ophiuchi		2096	6, 9	40 8	2 17	92 1	5	22 65	2	4 58	W S	Two nights, stationary
							92 8	5	22 37	2	5 56	S	
			B 43	8, 9	41 8	2 58	71 0	3	0 95	2	4 43	W	Position for 1870, Burnham est at 70° and 1″ in 1872
6840	21 Ophiuchi		[315]	6 2, 8 1	45 0	1 26	167 5	6	1 22	1	5 57	S	Motion doubtful, difficult, and [needs attention
							161 0	3	0 75	1	6 53	S Sm	
6842			2106	6, 8	45 0	9 37	329 8	4	0 4	est	5 57	S	Bad night, motion probable
6847	167 B Herculis		2107	6½, 8½	46 7	28 52	216 3	3			58	S	Binary
							215 5	5			59	S	
6867		AB	3107	8½, 8½	52 5	4 7	102 0	7	1 59	1	58	S	Some motion
		AC					42 1	2			58	S	
6888	P XVI 270		2114	6 2, 7 4	55 9	8 37	146 5	4	1 33	1	2 49	W	
6910	210 B Herculis		2120	6½ 9	59 5	28 16					3 48	S	Companion not seen, a binary
							258 2	4	4 17	2	5 57	S	
6935	μ Draconis		2130	4 4½	17 2 8	54 38	171 8	4	2 64	2	57	S	Binary
							171 9	6	2 53	3	6 58	W S	
	Lalande 31224		B 124	8, 10	4 0	— 0 37	263 0	2	0 9	est	4 43	W	Difficult, position for 1870, Burnham estimated at 250° and 1″ in 1873
6973			2145	8 9½	11 4	26 41	178 8	4	12 93	2	6 47	W S	Motion certain
			B 45	9, 9½	13 1	32 37	287 0	3	4 84	2	4 43	W	Position for 1870, Burnham est at 290° and 5″ in 1870
			B 46	8, 12	17 6	13 31	192	est	2 7	est	43	W	

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				h m	° ′	°		″				
7016	ρ Herculis	2161	4, 5½	17 19 2	37 18	312 6	11	3 85	2	6 48	W S Sm	Slow motion
7028	281 B Herculis	2165	7, 8½	21 3	29 33	52 5	4	7 42	2	5 57	S	Slow motion
						52 6	4	7 54	2	6 58	W S	
7035		2168	7 5, 8 2	22 2	35 51	200 7	4	2 23	2	58	W S	Stationary
7040		2173	6, 7	24 1	− 0 55	327 8	7	1 0	est	5 57	S	A binary
7069		2186	7 5, 7 5	29 6	1 5	84 0	4	2 72	5	6 58	W S	Bad definition, stationary
7076	P XVII 163	2190	6, 9½	30 8	21 5	23 4	4	10 55	2	48	W S	Decided motion
						26 4	3	10 61	2	58	W S	
7088	315 B Herculis	2192	7½, 10	35 1	29 18	73 5	4	10 54	2	5 58	S	Decided motion
7104		2199	7, 8	35 9	55 51	100 4	9	1 73	2	58	S	Decided motion, orbital
7131	331 B Herculis	2213	8, 8½	40 0	31 11	331 7	4	4 18	2	6 58	W S	Stationary
7142	μ_ Herculis	AC 7	10, 10	41 6	27 49					4 57	W S	Failed, a binary
										5 58	S	Not divided
						56 0	est			7 47	S	W uncertain, night not very good
7169		2232	7, 8 5	45 0	25 18	140 3	5	6 41	3	6 60	W S	Stationary
7173		2234	9, 9	46 1	− 7 56	201 1	4	16 54	1	5 58	S	Stationary
7177		[338]	6 6, 6 9	44 3	15 21	25 4	7	0 83	3	7 45	W	Stars neatly divided
						26 6	7	0 86	2	46	W Sm	A binary
7187		2240	9 10	47 4	5 17	202 0	4	3 37	1	5 58	S	Very difficult, neatly stationary
7192		2242	7 8, 7 8	47 7	44 56	327 5	5	3 45	3	6 53	S Sm	Stationary
7195		AC 8	5 8	48 3	29 42	245 1	4			5 62	S	Elongated only, change doubtful
7205	9 B Tauri Poniat	2244	6 9 7 1	50 6	0 7	276 9	4	1 32	3	1 56	W S	Stationary
						276 3	6	1 17	3	6 60	W S	
7212		2246	7, 8	51 2	39 32	107 2	5	5 5	est	58	W S	Very slow
7216		2250	8, 9	52 6	− 6 51	343 4	4	7 59	2	60	W S	Very slow
7220		2252	8, 8	52 7	2 2	25 5	6	3 70	2	5 58	S	Very slow
7237		2258	8½, 8½	53 4	48 39	222 6	4	2 27	2	62	S	Stationary
7245	τ Ophiuchi	2262	5 6	56 1	− 8 10			1 67	2	2 49	W	Position zero slipped, a binary
						249 9	5	1 71	3	6 60	W S	

7246			2263	7, 8	55 9	26 34	160 1	4	7 35	2	60	W S	Stationary
7262			2267	8, 8	57 6	40 11	241 1	6	1 09	3	60	W S	Measures bad, eyes tired
7273	70 Ophiuchi	p	2272	4½, 7	59 1	2 33	85 1	4	3 49	2	5 62	S	Binary
							80 5	4			6 61	W	Too unsteady for distance
							80 4	6	3 37	3	61	W S	
7283	P XVII 362		2276	6½, 7	59 9	12 2	258 9	4	6 64	2	5 62	S	Stationary
7292	72 Ophiuchi		[342]	4, 8	18 1 4	9 33					62	S	Elongated only
7308	414 B Herculis		2282	7 2, 8 2	2 4	40 22	90 2	5	2 38	3	6 61	W S	Stationary
7309	73 Ophiuchi		2281	6, 7½	3 2	3 58	254 7	5	1 12	2	5 62	S	Binary
							252 9	4	1 19	2	6 55	W	
							253 9	5	1 14	3	61	W S	
7322	417 B Herculis		2289	6½, 7½	4 4	16 27	237 2	4	1 12	2	5 63	S	Very unsteady, slow motion
							235 3	4	1 39	2	6 55	W	
							234 5	4	1 33	2	61	W S	
7327	μ Sagittarii	AD		3½, 9½ 10	6 3	−11 6	115 0	2			5 63	S	Stationary
		AC					312 5	2			63	S	
7354			2298	8 5, 9 7	8 5	41 23	178 4	4			62	S	Slow motion
7385			2309	7½, 8½	15 2	25 28	350 5	5	4 03	2	6 61	W S	Very slow
7387			2310	7, 10	15 3	22 46	237 6	4	5 25	1	5 62	S	Very slow
7393			2313	7, 8½	18 0	− 6 40	197 7	4	6 15	2	6 61	W S	Stationary
7419		AB	2319	7 2, 7 5	22 3	19 14	193 2	5	5 60	3	1 58	W K	Stationary
							191 5	9	5 74	4	6 61	W S	
		AC					273 8	2	41 80	1	1 58	W	
7425	39 Draconis	AB	2323	5, 8½, 7	22 0	58 44	3 4	3					Some motion
		AC					21 6	3	40	est	5 74	S	
7479			[358]	6 8, 7 2	31 6	16 54					7 47	W S	No companion seen Is this the [star?
7481			2346	7 5, 9	31 2	7 25	289 2	4	18 77	2	62	S	Probably rectilinear motion
7501	α Lyræ			1, 10 5	32 7	38 40	151 8	4	57 64	4	1 58	S	Two nights
							152 5	6	49 09	1	2 72	W S	
							152 2	6	47 50	2	3 45	S	
							154 0	3	48 4	3	4 70	W S	Motion
							154 5	5			62	S	
7505			2356	8 5, 9	33 4	28 36	56 8	7	0 98	1	5 62	S	Slow motion

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				h m	° ′	°		″				
7510		2360	7 5, 8 7	18 34 0	20 49	2 6	4	2 36	2	5 63	S	Very slow motion, if any
7545		2373	8 9	38 9	−10 37	337 9	8	4 69	1	6 61	W S	Stationary
7551	ε₁ Lyræ 4	2382	5 6 5	40 2	39 33	17 4	11	3 22	6	59	W S	Three nights, a binary
7556	ε₂ Lyræ 5	2383	5 5 5	40 2	39 29	139 4	12	2 62	7	59	W S	Three nights, a binary
7588		2394	9 9	41 3	41 57	204 5	4	6 35	2	5 74	S Sm	Stationary or very slow
7593		2396	8, 11	42 7	10 39	311 9	4	19 92	2	63	S	Rapid rectilinear motion
7599		2402	8 8½	43 9	10 33	207 1	4	0 8	est	63	S	Slow motion
7615		2404	7 8	44 9	10 50	184 1	4	3 94	2	6 61	W S	Stationary
7620	P XVII 226	2410	8 9	45 0	59 11	95 9	4	1 54	2	3 58	S	Very delicate, stationary
						94 2	4	1 34	3	4 72	W S	
						95 1	4			5 63	S	
						96 0	5			74	S Sm	
7675	11 Aquilæ	2424	6, 9	53 1	13 29	255 9	4	17 29	2	63	S	Rectilinear motion
7683		2426	7, 8	54 2	12 45	78 6	4	16 92	2	63	S	Stationary
7685	P XVIII 263	2428	8 9	54 3	14 46	287 4	4	6 00	2	6 61	W S	Stationary
7689		2429	8 3, 9 8	54 1	36 17	285 1	4	5 15	2	48	W S	Stationary
						289 8	8	5 34	2	61	W S	
7702	P XVIII 274	2434	8, 8 5	56 3	− 0 54	133 4	3	24 18	2	5 66	S	C not visible, decided motion
7703		2436	7 8	56 2	8 35	310 4	3	33 46	2	63	S	Stationary, or very slow
7706		2437	8, 8	56 4	19 0	68 0	4	0 8	est	6 52	S Sm	Some motion
7752		2454	8 9	19 1 3	30 15	232 4	4	0 79	1	63	S	Clearly divided, decided motion
7754				1 5	35 41	194 0	4	2 63	2	61	W S	Fixed
7762	17 Lyræ	2461	6, 10	2 6	32 19	323 7	5	4	est	61	W S	Slow motion
						320 1	4	3 86	2	63	S	
7768		2464	8 10½	3 3	11 42	29 9	3			5 68	S	Distance less than 1″, probable binary
						27 2	4	1 0	est	6 63	S	
						22 4	4			64	S	Night bad
7777	P XIX 8	2469	7½ 9	3 5	38 43	122 5	4	1 17	1	5 63	S	Stationary
7819		2484	7½ 9	8 8	18 53	225 0	4	2 71	2	63	S	Perhaps some motion

							223 6	5			64	S	Night bad
7828	6 B Cygni		2486	6 6½	8 8	49 36	225 3	4	2 85	2	66	S	
7832	Lalande 36205		S 715	8, 8½	10 5	−16 12	221 3	4	10 26	2	66	S	Slight motion
7835			2488	7½, 8½	10 1	19 52	14 6	6	8 41	2	6 61	W S	Stationary, S gives 1 55 and [9 17 in 1826
							331 5	4	0 9	est	5 66	S	Certain motion, orbital
							328 3	4			67	S	
7843	Lalande 36228		S 716	9, 9½	10 9	−16 11	329 5	4	1 28	2	6 61	W	
7854			2491	8, 9	11 2	28 6	17 4	4	6 14	2	61	W S	Stationary, S gives 19 8 and [6 28 in 1824
							211 9	2	1 03	1	5 66	S	Slow motion
7858	23 Aquilæ		2492	5½, 9½	12 1	0 49	205 8	5			68	S	
							17 4	6			68	S	Bad definition
7951			2523	7 4, 7 5	21 5	20 56	12 4	7	3 70	2	69	S F	Seems stationary
7958	22 B Cygni		2525	7 1, 7 1	21 5	27 7	150 2	4	6 23	2	66	S	Stationary
8006		BC	2538	8, 8, 9	26 7	36 27	233 6	3			66	S	Certain motion, orbital
		AB					54 0	4	6 24	2	66	S	Nearly stationary
8008	P XIX 169	AB	2539	9, 11	27 2	28 0	246 7	2			66	S	
							7 1	5	6 37	2	68	S	Motion very slow
							4 7	4			69	S	
8024	P XIX 185		2541	8 2, 9 8	30 0	−10 42	6 6	5			70	S F	Through cloud
8037		AB	2544	7 2, 9 5, 11	31 1	8 2	330 2	4	2 76	2	6 61	W S	Stationary
		AC					240 9	5	16 87	1	5 67	S	Very slow
8042			2548	8, 9	31 3	24 44	214 6	1			67	S	
8043		AB	2545	6½, 8½, 11	31 7	−10 26	101 8	4	9 37	1	67	S	Stationary
							316 2	3	4 50	1	67	S	C not seen, stationary
							318 0	5	4 07	2	68	S F	
							319 4	7	3 63	2	6 61	W S	
		AC					320 1	4	3 60	1	62	W S	
							171 2	3			5 68	W S	
							170 5	3		est	6 61	W S	
8045		AB	2547	8, 8½, 10	32 0	−10 38	170 0	3	25	est	62	W S	
							330 0	4	21 40	2	3 57	S	Stationary
							331 0	1	20	est	6 61	W	The group 2541, 2545, 2547 are close together, and have often been confused, from their very close resemblance
							331 7	4	21 32	2	62	W S	

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				h m	°	°		"				
	AC					143 7	2			3 57	S	
						143 0	1	45	est	6 61	W	
						144 0	2	49	est	62	W S	
8119	P XIX 257	2570	7½ 9½	19 39 1	10 30	277 8	4	4 30	2	67	S	Stationary
8146		2576	7½ 7¾	40 7	33 19	126 7	4	3 52	2	·68	S	Slow motion
						125 0	2	3 14	2	61	W S	
8151	Lalande 37672	D 13	7½ 11¼	40 8	44 37	265	est	2 to 2 5	est	4 75	W	Probably stationary
8153	δ Cygni	2579	3½, 9	41 0	44 50	336 8	5	1 70	1	2 78	S	Binary
						339 1	7			4 70	W	Two nights
						335 8	7			5 70	S F	
8159	17 Cygni	2580	5 8	41 5	33 28	72 7	6	25 93	2	68	S F	Stationary
8168	π Aquilæ	2583	6 7	42 9	11 30	120 3	5	1 66	2	68	S F	Fixed
8169		D 10	8 9	42 6	23 56	322 7	4			68	S F	No certain change
8180	α Aquilæ		1½, 10 2	44 6	8 32	312 9	4			68	S F	Motion
8257		A C 16	7¼, 8	52 6	26 55	232 0	5	0 5	est	69	S	Probably no change
8325	AB	2624	7, 8, 9½	58 4	35 41	176 8	4	2 06	2	·70	S	Cloudy, stationary
	AC					328 8	2			70	S	
8328		2626	8 8	59 1	30 11	130 1	12	0 98	1	70	S F	Three nights, some motion.
8359	P XIX 415	2631	8 10	20 1 9	20 45	341 2	6	4 70	2	71	S F	Stationary
8386		2640	7, 10	3 2	63 30	23 6	6	5 36	2	70	S Sm	Bears illumination very well, motion slow
8388		2636	8 2, 9 2	4 8	− 4 57	113 6	5	19 82	1	71	S F	Rapid motion, or an error
8403	P XX 26	2644	7, 7 2	6 2	0 28	210 9	5	3 37	2	71	S F	Nearly stationary
						211 3	6			72	S F	
8411		[400]	7 2, 8 2	6 0	43 36					3 62	S	Not divided
										6 77	S	Not divided, perhaps elongated
8449	250 B Aquilæ	2656	7, 11½	9 4	7 28	113 5	4	30	est	5 72	S	Is this the right star?
8452	153 B Cygni	A C 17	6 11½	9 0	51 5	82 7	3			71	S T	Probably stationary
8457		2658	6 5 9	10 2	52 43	125 1	4	4 89	2	6 77	S Sm	Stationary

8472			2662	8, 11	12 7	10 38	45 9	5			5 72	S F	Very doubtful
							37 6	3			75	S	Probably stationary
8493	172 B Cygni		2666	6½, 8½	13 5	40 21	246 2	6	2 53	2	72	S F	Very slow
8512	176 B Cygni		2668	7, 9	15 5	39 1	288 3	6	3 05	2	72	S F.	Perhaps slow motion
8516			[406]	7 1, 8	15 7	44 58	306 4	2	0 4	est	6 72	S Sm	Almost round, bad night
8519		AB	2673	8, 9½	16 9	12 56	333 6	5			5 74	S Sm	Stationary
and			and				333 6	4			72	S F	
8520		AC	2674	8, 11			101 1	2			72	S F	
							105 0	2			74	S Sm	
		CD					3 8	3			72	S F	
							2 6	2			74	S Sm	
8528			2676	8, 10	17 4	26 44			2 40	2	4 77	W S	Night bad, position readings [valueless
							173 5	10	2 42	2	5 72	S F	Good readings
8600	P XX 177, 178 AB		2690	7½, 8	25 2	10 51	256 5	2	15 09	1	74	S	C and D not seen, very slow change
8620	44 Cygni		A C 18	6½ 11½	26 2	36 31	170 6	2			75	S	Differs from S in 1873, perhaps some motion, needs further measures
8624			2696	8 8½	27 2	5 3	306 0	5			75	S Sm	Nearly stationary
8649			2699	8 9	29 9	−13 7	195 0	3	9 33	1	74	S	Stationary
							194 6	3	8 90	1	75	S Sm	
8663	β Delphini		2704	3 11	31 6	14 9	338 9	3			74	S	Some motion, C not seen
8692			2708	7 8 3	33 8	38 11	336 6	5	21 28	2	74	S	Rapid rectilinear motion
							333 2	3	22 08	2	6 77	S	Night windy
8694			2706	8 11	34 4	− 1 33	35 9	3			5 74	S	Stationary
							37 6	4			75	S	
8755	52 Cygni		2726	[illegible]	40 5	30 14	57 2	3			74	S	Very slow motion
8773	λ Cygni		[413]	5 6 3	42 5	35 2	64 8	4	0 65	1	76	S	Certain binary
8784	4 Aquarii		2729	5 9 7 2	44 7	− 5 6					6 86	S Sm	Not divided
8788			2730	8 8	44 8	5 56	337 4	4	3 31	2	5 76	S	Stationary
							338 0	4	3 25	2	79	S Sm	
8811			[416]	7 8 8 1	47 7	43 17	139 8	5	[illegible] 35	2	6 78	W S	Certain motion
8812			2734	8 8½	48 2	12 37	171 7	1	27	[illegible]	77	S	Certain motion
8827			2736	[illegible]	[illegible]	12 2	222 5	4	[illegible]	2	[illegible]	S	[illegible]

Herschel's Number	Name of Star		Struve's or other Number	Mags	R A 1875	Dec 1875	Position Angle	No of Obs	Distance	No of Obs	Date 1875+	Observers	Remarks
					h m	°	°		″				
							221.2				5.80	S	
8839	ϵ Equulei	AB	2737	5½, 7½, 7½	20 52.8	3 48	289.2	4	1.12	1	79	S Sm	Triple system, certain motion
		AC					77.5	3	9.65	1	79	S Sm	
8850	P XX 429		2741	6 7½	54.5	49 58	32.2	7	1.97	1	79	S Sm	Stationary
8860			2744	6.3, 7½	56.8	1 4	174.5	6	1.31	1	79	S	Certain motion
8868			2746	8, 8.6	56.9	38 45	290.3	5	1.09	2	6.78	W S	Slow motion, orbital
8898	61 Cygni		2758	5½, 6	21 0.9	38 6	117.0	7	19.40	1	5.79	S Sm	
							115.9	6	19.59	3	6.59	W S	Binary
							116.2	10	19.68	4	60	W S	
							115.8	8	19.96	3	61	W S	
							116.6	4	19.66	3	61	W S	
							116.2	5	19.72	5	62	W	
8917	P XXI 1		2762	6½ 9	3.3	29 43	313.2	6	3.35	2	5.79	S Sm	Stationary
8927			2767	8, 8¼	4.8	19 28	33.4	5	2.92	2	80	S	Stationary
8951			[431]	7.6, 8.0	6.8	40 46	119.4	4	2.95	2	80	S Sm	Stationary
8959	δ Equulei		2777	4, 10	8.4	9 30	24.8	2	38.00	2	6.78	W Sm	Rapid rectilinear motion
							23.7	2	37.31	1	85	S Sm	
8976	P XXI 50		[432]	6.8, 7.2	9.5	40 38	128.7	4	1.17	1	5.80	S	Stationary
9005	27 B Equulei		2786	7, 8	13.6	8 57	188.2	4	2.70	2	6.78	W S	Very slow motion
9021			[437]	6.5, 7.2	15.0	31 55	51.3	7	1.59	2	5.81	S Sm	Certain motion
							52.2	4	1.53	2	6.78	W S	
9072	20 B Pegasi		2799	6.5, 7.4	22.9	10 34	312.4	4	1.26	1	5.81	S	Binary
9107	29 B Pegasi		2804	7 8	27.1	20 11	326.7	4			81	S	Binary
9134			[443]	8, 8.3	31.5	6 9	349.4	5			81	S Sm	Quite stationary
9161	L 42240		D 15	7½, 11	33.6	42 44	73.6	4			89	S Sm	Definition perfect, stationary
9184	75 Cygni		A C 20	5½, 11	35.3	42 42					3.73	W S	B not seen
9210	μ Cygni		2822	4.3, 7	38.4	28 12	118.2	4	3.65	1	5.81	S	Slow motion
							119.4	3	4.05	2	6.78	W S	
							119.4	4	3.84	1	83	S	

9213	κ Pegasi		2824	4, 10	39 0	25 5	303 3	5			5 89	S	Some motion
9226			2825	8, 8 2	40 1	0 19	113 3	5	1 06	2	6 86	S	Some motion probable
							108 0	3			86	Sm	
9240		AC	2828	8, 9 9 2	43 1	2 47	134 5	2			5 81	S	Some change in distances
		AC					134 2	2	25 78	1	89	S	
		AB					143 4	2	26 15	1		S	
		BC					38 5	2	3 93	1		S	
9273			2837	8 5, 9	43 0	82 22	302 2	4	2 57	2	6 94	W S	Night as bad as can be, motion [certain
9283	100 B Aquarii	AB	2838	6, 9	47 8	− 3 52	round				85	S Sm	
		AC					186 0	4	21	2	88	S	Stationary
9300			[452]	7 7, 8 8	49 4	6 38					3 73	W	Not found or not divided
							177 7	3			6 88	S Sn	Stationary
9308		AB	2846	8 5, 10 3 10	49 7	45 12	269 0	4			5 89	S	Stationary
		AC					155 2	2	dist		89	S	
9325			2847	7 6, 8	51 3	− 4 5	305 1	4	1 38	2	6 88	S	Perhaps some motion
9376			2854	7 7 8	58 1	13 3	83 4	4	3 32	2	83	W S	Stationary
9388			2856	8 8	59 5	4 14	202 8	2	0 93	1	5 89	S	Stationary
9449		AC	[464]	7 8, 8, 10	22 58	39 33	353 7	2	33 00	2	6 83	W S	B not seen
9466	148 B Pegasi		2878	7[illegible], 9	8 3	7 19	132 2	4	1 45	2	5 92	S	Stationary
9474			2881	6 7, 7 3	8 2	28 55	103 2	4	1 52	2	92	S	Some motion
9539	33 Pegasi	AC	2900	6 8 9 2	17 6	20 13	330 2	1	68 50	4	6 83	W S	B not seen, C changes distance rapidly, movement seems rectilinear
9580	ζ Aquarii		2909	4, 4 2	22 3	− 0 40	335 0	5			5 92	S Sm	Binary
							336 1	4	3 48	1	6 85	W	
9581			2910	8 9	22 3	22 55	343 0	4	5 62	1	5 92	S Sm	Very slow
9593	37 Pegasi		2912	6, 7	23 6	3 48	122 3	1	0 5	est	1 92	S	Some change
9628			2920	7 1, 8 2	28 0	3 34	144 2	4	13 54	4	68	W	Stationary
9670			2928	8, 8	32 9	−13 16	319 5	4			5 97	S	Motion, orbital
9703			2934	7 7, 9	35 8	20 48	158 0	4			97	S	Difficult, decided motion
9715			[476]	6 8 7 2	37 6	46 29					2 82	W H	Failed entirely to agree, very [close
9742	P XXII 219	AC	2944	7, 7, 8	41 2	− 4 53	142 5	3			5 97	S	Rectilinear motion
		AB					253 7	4	3 51	2		S	

Herschel's Number	Name of Star		Struve's or other Number	Mags	R A 1875	Dec 1875	Position Angle	No of Obs	Distance	No of Obs	Date 1870+	Observers	Remarks
					h m	° '	°		"				
		BC					136 2	3				S	
9820	263 B Pegasi		2958	6, 9	22 50 5	11 11	11 2	4	3 70	1	5 97	S	Very slow
9901		AC	2976	8 5, 9 8, 9 9	23 1 5	5 55	186 7	2	16 81	1	97	S	Some change certain.
		AB					265 1	2					
		BC					161 2	2			·		
9968			2995	8, 8	9 9	− 2 17	29 6	5	5 29	2	97	S	Nearly stationary
9982	94 Aquarii		2998	5 2, 7 2	12 4	−14 8	346 6	4	13 83	2	97	S	Stationary
10004			3006	8½, 9	15 3	34 45	168 0	3	5 09	2	3 79	W S.	Position readings varied, motion certain
10170			3037	7 8 5	39 8	59 46	211 3	3	2 89	2	83	W S	Definition good, stationary
10175			3039	7 9	40 5	27 44	36 2	3	30	est	6 06	S	Stationary
10252			[513]	7, 9 5	51 9	34 20	19 1	8			1 78	W A M W	No measures of distance possible, definition bad, stationary.
10258	37 B Andromedæ		3050	5 7, 6 3	53 2	33 3	203 6	4	3 09	2	6 06	S	Motion certain
10304			3062	6½, 7 3	59 6	57 44	298 8	6	1 44	3	93	W S	Night not very good, position uncertain, a binary

IV. *Theory of the Horizontal Photoheliograph, including its application to the determination of the Solar Parallax by means of Transits of Venus* By Prof WILLIAM HARKNESS, U. S. Navy.

(*Communicated by the Astronomer Royal*)

THE term "Horizontal Photoheliograph" is used to designate that form of photoheliograph which, it is believed, was first employed by the late Prof JOSEPH WINLOCK; and which consists essentially of a fixed telescope whose optical axis is accurately horizontal and in the meridian, and whose objective is directed toward the same side of the zenith as the elevated pole, the Sun's rays being reflected into the telescope by a suitable heliostat The sensitive plate for the reception of the photographic image is, of course, situated at the chemical focus of the telescope, the plane of the plate being perpendicular to, and its centre coinciding with, the optical axis of the telescope.

The details of the construction of the horizontal photoheliograph, in so far as they are necessary for a proper understanding of the theory of the instrument, are shown in Fig. 1 A is the heliostat mirror, consisting of a piece of highly polished, but unsilvered, glass, whose two surfaces make an angle of about sixty minutes with each other. The front surface is worked as truly plane as possible, and serves to reflect the solar rays through the objective to the photographic plate. In working the back surface, no

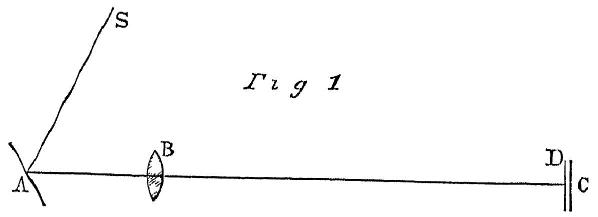
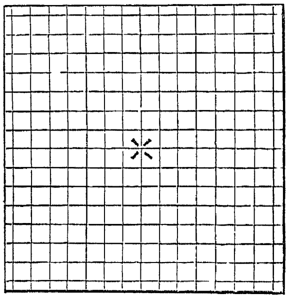


Fig 1

particular pains are taken, and, on account of its inclination to the front surface, any light reflected from it is thrown entirely away from the photographic plate B is the objective, which is corrected for the chemical, and not for the visual, rays The distance between the objective and mirror is made as small as possible, consistently with keeping the latter clear of the shadow of the former D is the reticule, the construction and use of which will be explained presently C is the photographic plate, the sensitive surface of which faces the objective The rays from the Sun, S, are reflected by the mirror A, through the objective B, and after traversing the reticule D they form an image upon the photographic plate C

Fig 2



The reticule consists of a system of squares, formed by the intersection of two systems of very fine straight lines, which are drawn upon one side, and respectively parallel to the edges, of a thin square plate of plano-parallel glass, as shown in Fig 2 In each of these linear systems the number of lines is odd, and the middle line is drawn through the centre of the plate This reticule is fixed at D, Fig 1, with its ruled surface toward, parallel to, and two or three millimeters distant from, the sensitive surface of the plate C Moreover, one of the two systems of lines is set as nearly as possible vertical, and its inclination is accurately determined, and to render assurance doubly sure, a plumb line, consisting of a silver wire about 0 05 of a millimeter in diameter is suspended between the reticule and the photographic plate, in such a position that it may hang freely, and at the same time be very nearly in the vertical plane passing through the centres of the reticule and objective As the light from the objective traverses the reticule before it reaches the photographic plate, the shadow, both of the reticule and of the plumb-line, is impressed upon every picture taken with the apparatus, and thus three different ends are gained First, by comparing the squares of the reticule with the corresponding ones upon the picture, everything relating to the shrinkage of the collodion can be determined, secondly, the impression of the plumb line, and also that of the vertical lines, furnishes upon each picture a fixed direction from which to measure angles of position, and thirdly, the intersection of the middle vertical with the middle horizontal line furnishes a fixed point, which will hereafter be designated as the centre of the plate To determine the zenith distance and azimuth of this point, it is necessary to measure the zenith distance and azimuth of the corresponding point of the reticule, as seen from the second principal point of the objective. For that purpose the mirror A, Fig 1, is temporarily removed, and a transit instrument is set up in front of the objective B, and in the prolongation of its axis The objective thus becomes a collimator to the transit instrument, through the eyepiece of which the lines of the reticule may be observed as if they were at an infinite distance It should be remarked, however, that, as the reticule is slightly inside the visual focus of the objective, it is not generally possible to obtain perfectly distinct vision of its lines and of the wires of the transit at the same time This difficulty is obviated by marking the intersection of the middle vertical and middle horizontal lines of the reticule in such a distinct manner that the slight maladjustment of focus does not prevent it from being seen Then, by means of the transit, the reticule is adjusted so that the point in question is very approximately in the meridian, and at a zenith distance of ninety degrees Finally, the exact azimuth and zenith distance of the point are measured

If the photoheliograph is employed to take a picture of any object whose linear magnitude is such that it subtends an angle a at the first principal point of the objective, and if the centre of the image coincides with the centre of the plate upon which it is taken, then, no matter what may be the solar focal distance of the objective, the magnitude of the image will be

$$2 \tan \frac{1}{2} a \, (D + E'' - T), \qquad (1)$$

where D is the distance between the back surface of the objective and the sensitive surface of the photographic plate, E″ the distance from the back surface of the objective to its second principal point, and T a correction due to the thickness of the reticule plate. It is thus evident that in all calculations involving measurements of pictures taken with this apparatus, the value to be employed as the focal distance of the objective is

$$D + E'' - T \qquad (2)$$

D is obtained by direct measurement, the accuracy of which must be such that the uncertainty of the resulting value will not exceed one part in ten thousand, and it is desirable that it should not exceed one part in forty thousand

To obtain E″, we put

n = refractive index of crown-glass lens,
n' = refractive index of flint-glass lens,
ne = thickness of crown-glass lens,
$n'e'$ = thickness of flint-glass lens,
s = space between the interior surfaces of the crown and flint lenses, measured along the optical axis,
$(n-1)f'$ = radius of first surface of crown lens This is the surface nearest the heliostat,
$(n-1)f''$ = radius of second surface of crown lens,
$(n'-1)f'''$ = radius of first surface of flint lens,
$(n'-1)f^{\text{iv}}$ = radius of second surface of flint lens,
ϕ° = focal distance of crown lens,
ϕ' = focal distance of flint lens,

Then, from the "Dioptrische Untersuchungen" given in GAUSS' *Werke*, vol. v., pp 262–265, we derive the formulæ

$$\phi^\circ = \frac{f'f''}{f'+f''-e}, \qquad \phi' = \frac{f'''f^{\text{iv}}}{f'''+f^{\text{iv}}-e'}, \tag{3}$$

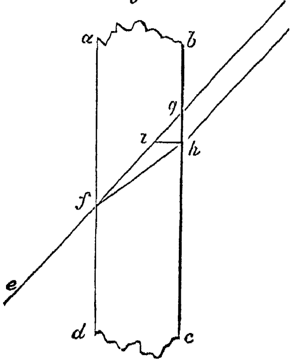
and if the objective is an ordinary double achromatic, corrected either for the visual or chemical rays,

$$\left.\begin{aligned} t' &= s + \frac{e\phi^\circ}{f'} + \frac{e'\phi'}{f^{\text{iv}}}, \\ E'' &= \phi'\left\{\frac{e'}{f'''} + \frac{t'}{\phi^\circ+\phi'-t'}\right\}, \end{aligned}\right. \tag{4}$$

but if it is a single lens, then

$$E'' = \frac{e\phi^\circ}{f'}. \tag{5}$$

Fig 3



To find the value of the correction T, let *abcd*, Fig 3, be a section of the reticule plate, and let *ef* be a ray of light incident upon it in the plane of the paper. If this ray suffered no refraction it would emerge from the plate at *g*; but, owing to refraction, it actually does emerge at *h*, after which its path is parallel to *ef* produced At *h* erect a perpendicular to *bc* It will be intersected at *i* by *ef* produced, and the distance *hi* will be the required value of T. Let *t* be the thickness of the glass composing the reticule plate; *n* its index of refraction, and *i* the angle of incidence of the ray *ef*.

Then

$$T = \frac{t\,(n-1)\cos i}{n}, \qquad (6)$$

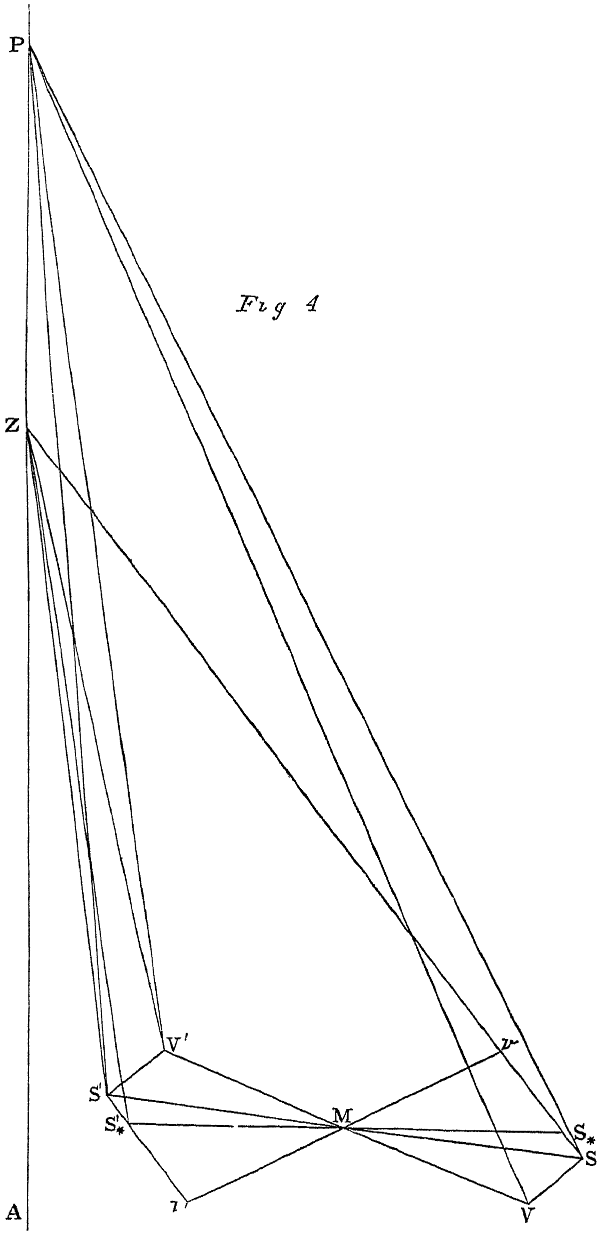
and as i cannot exceed half a degree, its cosine will be very nearly unity, and it will be sufficiently accurate to write

$$T = \frac{t\,(n-1)}{n}. \qquad (7)$$

If we assume the reticule plate to be of crown glass, and its refractive index to be 1 53, then $T = 0\ 347\,t$, and it is evident that, in order to make T small, the reticule plate should be as thin as possible

From the experience thus far had with the horizontal photoheliograph, it appears that if the focal distance of the objective is F, its clear aperture should be 0 0100 F The clear aperture of the heliostat mirror, which is circular in form, should be 0 0142 F The plates upon which the pictures are taken should be square, and of such a size that their sides, as seen from the centre of the objective, may subtend an angle of about sixty minutes. This should also be the size of the reticule plate, and the distance between any two consecutive lines of the reticule should subtend an angle of about four minutes Throughout the remainder of this paper it will be assumed that these are the proportions of the apparatus The actual focal distance of the objectives of the instruments heretofore constructed has generally been about twelve meters

To avoid repetition, the notation which will be employed throughout the remainder of this paper is here given Let PA, Fig 4, be the meridian of the place of observation, P being the pole, and Z the zenith. Let S be the position of the Sun as seen from the centre of the Earth, and S_* its position as seen from the place of observation Hereafter, to avoid circumlocution, S will be designated as the true, and S_* as the apparent, Sun Let v be the vertex of the apparent Sun, and V the position of *Venus* as seen from the centre of the Earth Also, let M be the point where the normal to the heliostat mirror pierces the heavens, and V', S', S'_*, and v', the positions of the reflected images of *Venus*, the true Sun, the apparent Sun, and the vertex of the apparent Sun as seen from the second principal point of the photographic objective Then the following notation will be adopted:—



ϕ' = colatitude of the place of observation = PZ = 90° − ϕ,
Δ_s = polar distance of true Sun = PS,

Δ_v = polar distance of *Venus* = PV,
Δ_s' = polar distance of the reflected image of the true Sun = PS$'$,
Δ_v' = polar distance of the reflected image of *Venus* = PV$'$,
t_s = hour-angle of the true Sun = APS,
t_v = hour-angle of *Venus* = APV,
t_s' = hour-angle of the reflected image of the true Sun = APS$'$,
t_v' = hour-angle of the reflected image of *Venus* = APV$'$,
ζ_s = zenith distance of the true Sun = ZS,
ζ_s' = zenith distance of the reflected image of the true Sun = ZS$'$,
ζ_s'' = zenith distance of the reflected image of the apparent Sun = ZS'_{*},
ζ_v' = zenith distance of the reflected image of *Venus* = ZV$'$,
A_s = azimuth of the true Sun = AZS,
A_s' = azimuth of the reflected image of the true Sun = AZS$'$,
A_s'' = azimuth of the reflected image of the apparent Sun = AZS'_{*},
A_v' = azimuth of the reflected image of *Venus* = AZV$'$,
θ = the angle $ZS'_{*}S'$,
r = the refraction,
π' = the parallax in altitude Hence, $r - \pi' = SS_{*} = S'S'_{*}$,
β = the angle ZS$'$V$'$,
γ = the angle ZV$'$S$'$,
λ = the angle PS$'$V$'$,
ρ = distance from the centre of the Sun to the centre of *Venus* = S$'$V$'$ = SV,
ω = position angle of *Venus* relatively to the centre of the Sun = PSV,
σ = the angle PVS,
χ = the angle PSS$'$,
ψ = the angle PS$'$S

We have next to show how pictures obtained with the horizontal photoheliograph may be measured, and the results expressed in terms of some one of the systems of spherical coordinates usually employed in astronomy

Upon an engine arranged to give polar coordinates, the plate to be measured is carefully adjusted, so that the centre of the image of the Sun coincides as accurately as possible with the origin of coordinates The fixed line, from which the angles of the coordinates are to be measured, is taken perpendicular to the image of the plumb-line, the zero being toward that edge of the plate which was on the right hand, as viewed from the object-glass, when the picture was taken, and (the collodion side of the plate being nearest the observer) a motion of the radius vector in the opposite direction to that of the hands of a watch corresponding to increasing angles. Then the distance from the origin of coordinates to the Sun's limb is measured at every thirty degrees, throughout the whole circumference, and the distances and angles to the centre of *Venus*, and to the centre of the plate, are also measured.

Owing to the effect of refraction, the outline of the Sun's image will not be circular, but may, with sufficient accuracy, be assumed to be an ellipse whose minor axis coincides with the vertical circle passing through the Sun's centre To find the position of the image of this vertical circle upon the photographic plate, we refer to Fig 4, and remark that, owing to the equality of the angles of incidence and reflection, $S_*M = S'_*M$, $vM = v'M$, and the angle S_*Mv is equal to the angle S'_*Mv' Hence $vS_*S'_* = S_*S'_*v'$, and $ZS'_*v' = ZS'_*S_* + S_*S'_*v' = ZS'_*S_* + ZS_*S'_*$ But ZS'_* is the direction of the plumb-line upon the plate, and S'_*v' is the semi-minor axis of the elliptical image of the Sun To find the value of the angle ZS'_*v' we require the zenith distance and azimuth of the true Sun, which are given by the formulæ (8), the necessary data being the exact instant at which the picture was taken, the right ascension and polar distance of the Sun, and the latitude of the place of observation We have

$$\tan M = \frac{\cot \Delta_s}{\cos t_s},$$

$$\tan A_s = \frac{\tan t_s \cos M}{\sin (\phi - M)}, \qquad (8)$$

$$\tan \zeta_s = \frac{\tan (\phi - M)}{\cos A_s}.$$

The zenith distance, ζ_s'', and azimuth, A_s'', of the reflected image of the apparent Sun are found by methods explained in a subsequent part of this paper Then, in the spherical triangle $ZS_*S'_*$, the angle $S_*ZS'_*$ is equal to $A_s \sim A_s''$, $ZS'_* = \zeta_s''$, and $ZS_* = \zeta_s - r + \pi'$, where r and π' are the refraction and parallax in altitude Whence, putting the angle $ZS'_*v' = 180° - \theta$,

$$\cot \frac{1}{2}\theta = \frac{\cos \frac{1}{2}(\zeta_s'' - \zeta_s + r - \pi')}{\cos \frac{1}{2}(\zeta_s'' + \zeta_s - r + \pi')} \cot \frac{1}{2}(A_s \sim A_s'') \qquad (9)$$

Thus the angle upon the photographic plate, between the fixed line of reference and the major axis of the image of the apparent Sun, will be θ; and if R and ϵ are the polar coordinates of any point of the limb of this image, its rectangular coordinates, referred to its axes and approximate centre, will be

$$\begin{aligned} y' &= \mathrm{R} \sin (\varepsilon \mp \theta), \\ x' &= \mathrm{R} \cos (\varepsilon \mp \theta), \end{aligned} \tag{10}$$

in which the upper signs are to be taken when the Sun is west, and the lower when it is east, of the meridian

Owing to atmospheric disturbances, the image of the Sun's limb will generally be more or less irregular, and, no matter how carefully it may be centred on the measuring engine, the point from which the measures are made will seldom coincide quite accurately with the centre of the image. On this account, to obtain the coordinates of any point of the limb referred rigorously to the centre and axes, the equations (10) must be corrected by the small quantities δy and δx, and thus we get

$$\begin{aligned} y &= \mathrm{R} \sin (\varepsilon \mp \theta) + \delta y, \\ x &= \mathrm{R} \cos (\varepsilon \mp \theta) + \delta x \end{aligned} \tag{11}$$

The image of the Sun's limb being taken as an ellipse, its equation will be

$$0 = -\mathrm{A}^2\mathrm{B}^2 + \mathrm{A}^2 y^2 + \mathrm{B}^2 x^2, \tag{12}$$

where A and B are respectively the horizontal and vertical semi-diameters of the Sun, affected by refraction and parallax Putting $\mathrm{B}^2 = n\mathrm{A}^2$, substituting this value in equation (12), and dividing by A^2, we get

$$0 = -n\mathrm{A}^2 + y^2 + nx^2 \tag{13}$$

Finally, substituting the values of y and x from the equations (11), neglecting the squares of δy and δx, and reducing, we obtain

$$0 = \begin{cases} +\frac{1}{2} \mathrm{R} \left[\sin^2 (\varepsilon \mp \theta) + n \cos^2 (\varepsilon \mp \theta)\right] \\ -\frac{n}{2\mathrm{R}} \mathrm{A}^2 \quad + \sin (\varepsilon \mp \theta) \, \delta y \\ \qquad\qquad + n \cos (\varepsilon \mp \theta) \, \delta x \end{cases} \tag{14}$$

Each measurement of the Sun's limb, made upon the photograph, gives one equation of the form (14), and from all the equations thus obtained the values of A, δy, and δx are found by the method of least squares

The contraction of the Sun's vertical semi-diameter on account of refraction will be $\frac{1}{2}(r'-r'')$; where r' and r'' are respectively the refraction of the lower and upper limbs The contraction of the horizontal semi-diameter on account of refraction, for all zenith distances less than 85°, may be taken as constant and equal to $0''.25$ Hence, if s represents the Sun's semi-diameter, we have

$$n=\left(\frac{s-\frac{1}{2}(r'-r'')}{s-0''.25}\right)^2, \tag{15}$$

which is the value to be employed in equation (14).

As changes of refraction are not strictly proportional to changes of zenith distance, the centre of the Sun's image will not coincide rigorously with the image of the Sun's centre Let the distance between those two points be δr, and let r''' be the refraction of the Sun's centre, r'' and r' being respectively the refraction of his upper and lower limbs, as before. Then

$$\delta r=\frac{1}{2}(r'+r'')-r''', \tag{16}$$

and the coordinates of the image of the Sun's centre are $\delta y+\delta r$ and δx These rectangular coordinates are transformed into polar coordinates of our original system by means of the formulæ

$$\left.\begin{aligned}
R&=[(\delta y+\delta r)^2+(\delta x)^2]^{\frac{1}{2}},\\
\sin\eta&=\frac{\delta y+\delta r}{R},\\
\cos\eta&=\frac{\delta x}{R},\\
\varepsilon&=\eta\pm\theta,
\end{aligned}\right\} \tag{17}$$

where the double sign is to be taken in the same way as in the equations (10)

The polar coordinates of the image of the centre of the apparent Sun have thus been found; and our original measurements gave the polar coordinates of the centres of the image of the apparent *Venus*, and of the photographic plate. Let R, R′, R″ be respectively the radii vectores, and ε, ε', ε'' the angles, of these coordinates. Passing now to a system of rectangular coordinates, whose origin is at the centre of the plate, and whose axis of X is parallel to the fixed line of the original system of polar coordinates, we get for the image of the centre of the apparent Sun

$$\begin{aligned} y &= R \sin \varepsilon - R'' \sin \varepsilon'', \\ x &= R \cos \varepsilon - R'' \cos \varepsilon'', \end{aligned} \qquad (18)$$

and for the image of the centre of the apparent *Venus*

$$\begin{aligned} y' &= R' \sin \varepsilon' - R'' \sin \varepsilon'', \\ x' &= R' \cos \varepsilon' - R'' \cos \varepsilon'' \end{aligned} \qquad (19)$$

Let it be assumed that, when the picture was taken, ζ_o and A_o were the zenith distance and azimuth of the centre of the plate, as seen from the second principal point of the objective, and that F was the reduced distance between the latter point and the sensitive surface of the plate, or, in other words,

$$F = D + E'' - T, \qquad (20)$$

as given by equation (2). Further, let the angles subtended at the second principal point of the objective by the coordinates y, x, y', x' of the equations (18) and (19) be respectively $\delta\zeta_s$, δA_s, $\delta\zeta_v$, δA_v Then, as the plate was perpendicular to, and its centre coincided with, the optical axis of the objective,

$$\begin{aligned} \tan \delta\zeta_s &= \frac{R \sin \varepsilon - R'' \sin \varepsilon''}{F}, \\ \tan \delta A_s &= \frac{R \cos \varepsilon - R'' \cos \varepsilon''}{F}, \\ \tan \delta\zeta_v &= \frac{R' \sin \varepsilon' - R'' \sin \varepsilon''}{F}, \\ \tan \delta A_v &= \frac{R' \cos \varepsilon' - R'' \cos \varepsilon''}{F}. \end{aligned} \qquad (21)$$

Denoting by ζ_s'', A_s'', ζ_v'', A_v'', the apparent zenith distances and azimuths of the reflected images of the Sun and *Venus*, as seen from the second principal point of the objective, we now have

$$\begin{aligned} \zeta_s'' &= \zeta_o - \delta\zeta_s, \\ A_s'' &= A_o + \delta A_s, \\ \zeta_v'' &= \zeta_o - \delta\zeta_v, \\ A_v'' &= A_o + \delta A_v \end{aligned} \qquad (22)$$

The next step will be to free these zenith distances and azimuths from the effects of refraction and parallax For that purpose, consider the spherical triangle $ZS'S'_*$, Fig 4, but instead of limiting the points S, S_*, S', S'_* to the Sun, let them represent any heavenly body whatsoever Then $ZS' = \zeta'$, $ZS'_* = \zeta''$, $S'S'_* = SS_* = r-\pi'$, $S'ZS'_* = A'' \sim A'$; and $ZS'_*S' = \theta$, the value of which is given by equation (9) The relations subsisting among these parts are

$$\begin{aligned} \tan m &= \tan\,(r-\pi')\cos\theta, \\ \sin\zeta'\cos\,(A''\sim A') &= \frac{\cos\,(r-\pi')\sin\,(\zeta''-m)}{\cos m}, \\ \sin\zeta'\sin\,(A''\sim A') &= \sin\,(r-\pi')\sin\theta \end{aligned} \qquad (23)$$

To simplify these equations we remark that $(r-\pi')$ will rarely amount to 5′, and as cosine θ must always be less than unity, we may write with all needful accuracy

$$m = (r-\pi')\cos\theta\,, \qquad (24)$$

ζ' will never differ from 90° by so much as 30′, and therefore its sine may be taken as unity; while, as $(A''\sim A')$ can scarcely amount to 5′, and will usually be far less, we may write unity for its cosine, and substitute the arc for its sine We thus find

$$\begin{aligned} \zeta' &= \zeta'' - (r-\pi')\cos\theta, \\ A' &= A'' \mp (r-\pi')\sin\theta. \end{aligned} \qquad (25)$$

As these equations are perfectly general, we have only to substitute in them, for ζ'' and A'', the apparent zenith distances and azimuths of the images of the Sun and *Venus*, given by the equations (22), and we thus obtain the true zenith distances and azimuths of the images of these bodies, which are

$$\begin{aligned} \zeta_s' &= \zeta_0 - \delta\zeta_s - (r_s-\pi_s')\cos\theta_s, \\ A_s' &= A_0 + \delta A_s \mp (r_s-\pi_s')\sin\theta_s, \\ \zeta_v' &= \zeta_0 - \delta\zeta_v - (r_v-\pi_v')\cos\theta_s, \\ A_v' &= A_0 + \delta A_v \mp (r_v-\pi_v')\sin\theta_s, \end{aligned} \qquad (26)$$

in which the upper signs are to be taken when the body is west, and the lower when it is east, of the meridian. Strictly speaking, the value of θ will not be the same for *Venus* as for the Sun, but the difference will generally be so slight that either value may be employed for both bodies. The effect of parallax in azimuth in displacing *Venus* relatively to the Sun's centre can never exceed 0″ 08, and will usually be much less; but if it is thought desirable to correct the equations (26) on that account, the mode of doing so will be obvious when it is remembered that it will be sufficiently accurate to consider the parallax in azimuth as acting perpendicularly to the parallax in altitude

From the zenith distances and azimuths given by the equations (26), the corresponding polar distances and hour angles must next be found. The rigorous formulæ for this purpose are

$$\begin{aligned} \tan m &= \tan \zeta' \cos A', \\ \tan t &= \frac{\tan A' \sin m}{\cos (\phi - m)}, \\ \cot \Delta &= \tan (\phi - m) \cos t, \end{aligned} \tag{27}$$

but A′ will generally be so small that its cosine may be taken as unity, and then we may write

$$\begin{aligned} \tan t &= \frac{\tan A' \sin \zeta'}{\cos (\phi - \zeta')}, \\ \cot \Delta &= \tan (\phi - \zeta') \cos t \end{aligned} \tag{28}$$

In the spherical triangle PS′V′, Fig 4, we have the relations

$$\begin{aligned} \tan m &= \tan \Delta_v' \cos (t'_s \sim t_v'), \\ \sin \rho \cos \lambda &= \frac{\cos \Delta_v'}{\cos m} \sin (\Delta_s' - m), \\ \sin \rho \sin \lambda &= \sin \Delta_v' \sin (t_s' \sim t_v') \end{aligned} \tag{29}$$

Usually it will be sufficiently accurate to put $\cos (t_s' \sim t_v') = 1$, and then $m = \Delta_v'$, and these equations become

$$\begin{aligned} \sin \rho \cos \lambda &= \sin (\Delta_s' - \Delta_v'), \\ \sin \rho \sin \lambda &= \sin \Delta_v' \sin (t_s' \sim t_v'), \end{aligned} \tag{30}$$

from which ρ and λ are obtained As a check, ρ may be computed directly from the zenith distances and azimuths furnished by the equations (26), the requisite formulæ being

$$\begin{aligned} \tan B &= \frac{(A_s' \sim A_v') \sin \zeta_s'}{\zeta_v' - \zeta_s'}, \\ \rho &= \frac{(A_s' \sim A_v') \sin \zeta_s'}{\sin B} = \frac{\zeta_v' - \zeta_s'}{\cos B}. \end{aligned} \tag{31}$$

From the spherical triangle PSS′, Fig. 4, we get

$$\left.\begin{aligned} \tan \tfrac{1}{2} (\chi+\psi) &= \frac{\cos \tfrac{1}{2} (\Delta_s'-\Delta_s)}{\cos \tfrac{1}{2} (\Delta_s'+\Delta_s)} \cot \tfrac{1}{2} (t_s' \sim t_s), \\ \tan \tfrac{1}{2} (\chi-\psi) &= \frac{\sin \tfrac{1}{2} (\Delta_s'-\Delta_s)}{\sin \tfrac{1}{2} (\Delta_s'+\Delta_s)} \cot \tfrac{1}{2} (t_s' \sim t_s) \end{aligned}\right\} \qquad (32)$$

Referring again to Fig 4, it is evident that SV is the distance, and PSV the position angle, of *Venus* from the centre of the Sun To find the values of these quantities we have

$$\begin{aligned} \mathrm{SV} &= \mathrm{S'V'} = \rho, \\ \mathrm{PSV} &= \mathrm{PSS'} \pm \mathrm{S'SV} = \mathrm{PSS'} \pm \mathrm{SS'V}, \\ &= \mathrm{PSS'} \pm \mathrm{PS'S} \mp \mathrm{PS'V'} \end{aligned} \qquad (33)$$

But PSV $=\omega$, PSS′ $=\chi$, PS′S $=\psi$, PS′V′ $=\lambda$, and thus we get

$$\omega = (\chi \pm \psi) \mp \lambda, \qquad (34)$$

in which the upper signs are to be taken when PS′S is greater than PS′V′, and the lower when the contrary is the case If it is assumed that the pole which forms part of the triangle PSV is always the elevated one, and also that position angles are counted from the north around by the east; then, in the northern hemisphere, when the Sun is east of the meridian the position angle will be $360°-\omega$, while west of the meridian it will be ω, and, in the southern hemisphere, when the Sun is east of the meridian the position angle will be $180°+\omega$, while west of the meridian it will be $180°-\omega$

Finally, if the polar distance of *Venus*, and the difference between her right ascension and that of the Sun are required, these quantities may be obtained from the spherical triangle PSV by means of the formulæ

$$\begin{aligned} \tan n &= \tan \rho \cos \omega, \\ \tan \Delta_v \cos (\alpha_s \sim \alpha_v) &= \tan (\Delta_s - n), \\ \tan \Delta_v \sin (\sigma_s \sim \alpha_v) &= \frac{\sin n \tan \omega}{\cos (\Delta_s - n)}, \end{aligned} \qquad (35)$$

in which α_s and α_v are respectively the right ascensions of the Sun and of *Venus*

In the preceding development of the theory of the horizontal photoheliograph, continual reference has been made to the centres of the Sun and *Venus*, but of course it will be understood that all the equations apply equally well to any other pair of celestial objects which may have been photographed with the same apparatus

As the horizontal photoheliograph was much used in observing the last transit of *Venus*, it is perhaps desirable to give here a direct method of deducing the solar parallax from the photographs then obtained For that purpose consider the quadrilateral PZS′S, which is composed of the triangles PZS′ and PS′S In the triangle PZS′ we have the relation

$$\sin A_s' \cot B = \sin \zeta_s' \cot \phi' + \cos \zeta_s' \cos A_s', \tag{36}$$

in which ϕ' is the co-latitude ZP, and B is the angle ZS′P Considering all the parts except ϕ' as variable, and differentiating, we get

$$dB = \begin{cases} -\dfrac{\sin^2 B}{\sin A_s'} \cos \zeta_s' \,(\cot \phi' d\zeta_s' + \sin A_s' dA_s') \\ +\cos A_s' \left(\dfrac{\sin^2 B}{\sin A_s'} \sin \zeta_s' d\zeta_s' - \dfrac{\sin B}{\sin A_s'} \cos B \, dA_s'\right) \end{cases} \tag{37}$$

To obtain approximately the maximum value of this differential, we remark that A_s' can never exceed ± 13′, and as sin B must always be less than sin A_s', $\dfrac{\sin B}{\sin A_s'}$ must be less than unity, and $\dfrac{\sin^2 B}{\sin A_s'}$ must be less than sin A_s', that is, it must be less than 0·004. ζ_s' can never differ from 90° by more than ± 13′, and therefore its sine may be taken as unity, and its cosine cannot exceed 0·004. If the latitude of the place of observation is less than 50°, ϕ' will be greater than 40°, and its cotangent will be less than 1·20. Substituting these values in the second member of equation (37), all the terms except the last become evanescent, and we may write, without an error of one part in ten thousand,

$$dB = -dA_s' \tag{38}$$

But the only way in which A_s' can be made to vary is by varying the adopted value of the solar parallax, π_s Hence, as ZS′ is nearly 90°, dA_s' is the resolved value of $d\pi_s$, and as it can never exceed that quantity, it is safe to write

$$dB = -d\pi_s \tag{39}$$

In the triangle PSS′ we have the relations

$$\begin{aligned}\cos\chi &= -\cos\psi\cos(t_s\sim t_s')+\sin\psi\sin(t_s\sim t_s')\cos\Delta_s,\\ \cos\psi &= -\cos\chi\cos(t_s\sim t_s')+\sin\chi\sin(t_s\sim t_s')\cos\Delta_s'\end{aligned}\qquad(40)$$

Considering all the parts as variable, differentiating, and reducing, we get

$$\begin{aligned}d\chi &= \sin\Delta_s'\sin(t_s\sim t_s')\,d\Delta_s-\cos\Delta_s'\,d\,(t_s\sim t_s')-\cos SS'd\psi,\\ d\psi &= \sin\Delta_s\sin(t_s\sim t_s')\,d\Delta_s'-\cos\Delta_s\,d\,(t_s\sim t_s')-\cos SS'd\chi\end{aligned}\qquad(41)$$

Adding, this becomes

$$d\chi+d\psi=\frac{\sin(t_s\sim t_s')\,(\sin\Delta_s d\Delta_s'+\sin\Delta_s' d\Delta_s)-d\,(t_s\sim t_s')\,(\cos\Delta_s+\cos\Delta_s')}{1+\cos SS'}.\qquad(42)$$

To obtain approximately the maximum value of this differential, we remark that at the time of the transit the Sun's north polar distance was 112° 49′, and therefore $\sin\Delta_s=0.922$, and $\cos\Delta_s=0.388$. If the latitude of the place of observation is not greater than 50°, the value of Δ_s' will lie between 130° and 180°; and consequently its sine will not exceed 0.766, and its cosine cannot be greater than unity. $\sin(t_s\sim t_s')$ cannot exceed unity Further, as the triangle PSS′ can only be varied by varying the assumed value of the solar parallax,* $d\Delta_s$ and $d\Delta_s'$ are the resolved values, and $d\,(t_s\sim t_s')$ is the sum of two resolved values, of $d\pi_s$. It is therefore certain that $d\Delta_s$ and $d\Delta_s'$ are not greater than $d\pi_s$, and that $d\,(t_s\sim t_s')$ is not greater than $2d\pi_s$. Substituting these values in equation (42), and adding all the terms, without regard to sign, we get

$$d\chi+d\psi=\frac{4\frac{1}{2}\,d\pi_s}{1+\cos SS'}\qquad(43)$$

Hence, if SS′ does not exceed 120°, the value of $d\chi+d\psi$ cannot be so great as $9d\pi_s$ Adding to this the value of dB, from equation (39), we find that, under the circumstances specified above, the total variation of the sum of the angles ZS′S and PSS′ cannot be so great as $10 d\pi_s$ But it is not possible that the value of the solar parallax now generally adopted can be in error by so much as 0″ 2, and therefore the value of $10 d\pi_s$ cannot be so great as 2″, and will probably be less than 1″

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* Strictly speaking, although the point S′ can only be varied by varying the assumed value of the solar parallax, the point S can be varied, not only in that way, but also by varying the tabular place of the Sun In practice it will probably be best to neglect at first the errors of the solar tables, and afterwards, when they become known from the solution of the final equations, to compute rigorously the value of $d\chi+d\psi$ for each photograph, by means of (42), and in all cases where it exceeds two or three seconds, which will rarely happen, the corresponding conditional equations of the forms (55) and (56) may be corrected so as to accord with the new values of the solar elements, and a second solution will give very accurate results

Referring to the figure, it is evident that ZS′V′ + PSV = ZS′S + PSS′, or

$$\beta + \omega = \mathrm{ZS'S} + \mathrm{PSS'} \tag{44}$$

As the angle β must be obtained from measurements made upon a photograph, it is not probable that it can be depended upon to within 5″ It has just been shown that the right-hand member of (44) will not be vitiated so much as 2″ by any possible error in the adopted value of the solar parallax It therefore follows that the left-hand member of (44) may be regarded as constant, within the limits of error of observation, and thus it appears that

$$-d\beta = d\omega \tag{45}$$

In the triangle ZS′V′ we have

$$\left.\begin{aligned} \tan \frac{1}{2} (\beta+\gamma) &= \frac{\cos \frac{1}{2} (\zeta_v'-\zeta_s')}{\cos \frac{1}{2} (\zeta_v'+\zeta_s')} \cot \frac{1}{2} (\mathrm{A}_s' \sim \mathrm{A}_v'), \\ \tan \frac{1}{2} (\beta-\gamma) &= \frac{\sin \frac{1}{2} (\zeta_v'-\zeta_s')}{\sin \frac{1}{2} (\zeta_v'+\zeta_s')} \cot \frac{1}{2} (\mathrm{A}_s' \sim \mathrm{A}_v'), \end{aligned}\right\} \tag{46}$$

from which β and γ are derived In the same triangle we also have the relations

$$\left.\begin{aligned} \cos \rho &= \cos \zeta_v' \cos \zeta_s' + \sin \zeta_v' \sin \zeta_s' \cos (\mathrm{A}_s' \sim \mathrm{A}_v'), \\ \sin (\mathrm{A}_s' \sim \mathrm{A}_v') \cot \beta &= \sin \zeta_s' \cot \zeta_v' - \cos \zeta_s' \cos (\mathrm{A}_s' \sim \mathrm{A}_v') \end{aligned}\right\} \tag{47}$$

Considering all the parts as variable, differentiating, and reducing, we find

$$\left.\begin{aligned} d\rho &= \sin \zeta_v' \sin \gamma \, d (\mathrm{A}_s' \sim \mathrm{A}_v') + \cos \gamma \, d\zeta_v' + \cos \beta \, d\zeta_s', \\ -\sin \rho \, d\beta &= \sin \zeta_v' \cos \gamma \, d (\mathrm{A}_s' \sim \mathrm{A}_v') - \sin \gamma \, d\zeta_v' + \sin \beta \cos \rho \, d\zeta_s' \end{aligned}\right\} \tag{48}$$

Reverting to the equations (26), putting $\pi_s' = \mathrm{M}\pi_s$, $\pi_v' = \mathrm{N}\pi_v$, $\pi_s = m\pi_v$, where π_s and π_v are respectively the equatoreal horizontal parallaxes of the Sun and *Venus*; regarding π_v as the variable, and differentiating, we get

$$\begin{aligned} d\zeta_s' &= +m\mathrm{M} \cos \theta_s \, d\pi_v, \\ d\mathrm{A}_s' &= \pm m\mathrm{M} \sin \theta_s \, d\pi_v, \\ d\zeta_v' &= + \ \ \mathrm{N} \cos \theta_v \, d\pi_v, \\ d\mathrm{A}_v' &= \pm \ \ \mathrm{N} \sin \theta_v \, d\pi_v. \end{aligned} \tag{49}$$

Substituting these values in (48), writing unity for sin ζ_v', θ_s for θ_v, and $d\omega$ for $-d\beta$, we obtain

$$\begin{aligned} d\rho &= \cos \theta_s \left[\pm (m\mathrm{M} \pm \mathrm{N}) \sin \gamma \tan \theta_s + \mathrm{N} \cos \gamma + m\mathrm{M} \cos \beta \right] d\pi_v, \\ d\omega &= \frac{\cos \theta_s}{\sin \rho} \left[\pm (m\mathrm{M} \pm \mathrm{N}) \cos \gamma \tan \theta_s - \mathrm{N} \sin \gamma + m\mathrm{M} \sin \beta \cos \rho \right] d\pi_v \end{aligned} \tag{50}$$

From an ephemeris, the polar distances of the Sun and *Venus*, and the difference of their right ascensions, are taken, and thus two sides and the included angle are known in the triangle PSV The remaining parts are given by the formulæ

$$\begin{aligned} \tan \mu &= \tan \Delta_v \cos (\alpha_s \sim \alpha_v), \\ \sin \rho_o \cos \omega_o &= \frac{\cos \Delta_v}{\cos \mu} \sin (\Delta_s - \mu), \\ \sin \rho_o \sin \omega_o &= \sin \Delta_v \sin (\alpha_s \sim \alpha_v), \\ \sin \rho_o \sin \sigma \ &= \sin \Delta_s \sin (\alpha_s \sim \alpha_v), \end{aligned} \tag{51}$$

in which we write ρ_o and ω_o to distinguish the quantities deduced from the ephemeris from the similar quantities, ρ and ω, obtained from the photographs by means of the equations (30), (32), and (34).

Still considering the triangle PSV, we have the relations

$$\begin{aligned} \cos \rho_o &= \cos \Delta_s \cos \Delta_v + \sin \Delta_s \sin \Delta_v \cos (\alpha_s \sim \alpha_v), \\ \sin (\alpha_s \sim \alpha_v) \cot \omega_o &= \sin \Delta_s \cot \Delta_v - \cos \Delta_s \cos (\alpha_s \sim \alpha_v) \end{aligned} \tag{52}$$

Regarding all the parts as variable, differentiating, and reducing, we get

$$\begin{aligned} d\rho_o &= \sin \Delta_v \sin \sigma \, d\,(\alpha_s \sim \alpha_v) + \cos \omega_o \, d\Delta_s \qquad\qquad + \cos \sigma \, d\Delta_v, \\ -\sin \rho_o \, d\omega_o &= \sin \Delta_v \cos \sigma \, d\,(\alpha_s \sim \alpha_v) + \sin \omega_o \cos \rho_o \, d\Delta_s - \sin \sigma \, d\Delta_v \end{aligned} \tag{53}$$

If now α_s, α_v, Δ_s, Δ_v, π_s, and π_v are the tabular values of the right ascensions, polar distances, and parallaxes of the Sun and *Venus*, and if $\alpha_s + d\alpha_s$, $\alpha_v + d\alpha_v$, $\Delta_s + d\Delta_s$, $\Delta_v + d\Delta_v$, $\pi_s + d\pi_s$, $\pi_v + d\pi_v$ are the true values of the same quantities, then we must have

$$\rho + d\rho = \rho_o + d\rho_o,$$
$$\omega + d\omega = \omega_o + d\omega_o \qquad (54)$$

Substituting the values of $d\rho$, $d\rho_o$, $d\omega$, and $d\omega_o$ from (50) and (53), we obtain finally

$$0 = \begin{cases} \rho_o - \rho + \sin \Delta_v \sin \sigma \, d\,(\alpha_s \sim \alpha_v) + \cos \sigma \, d\Delta_v + \cos \omega_o \, d\Delta_s \\ -\cos \theta_s \, [\pm(mM \pm N) \sin \gamma \tan \theta_s + N \cos \gamma + mM \cos \beta] \, d\pi_v, \end{cases} \qquad (55)$$

$$0 = \begin{cases} \omega_o - \omega - \dfrac{1}{\sin \rho_o} [\sin \Delta_v \cos \sigma \, d\,(\alpha_s \sim \alpha_v) - \sin \sigma \, d\Delta_v + \cos \rho_o \sin \omega_o \, d\Delta_s] \\ -\dfrac{\cos \theta_s}{\sin \rho} [\pm(mM \pm N) \cos \gamma \tan \theta_s - N \sin \gamma + mM \sin \beta \cos \rho] \, d\pi_v \end{cases} \qquad (56)$$

Each photograph furnishes one conditional equation of the form (55), and another of the form (56), and from all the equations thus obtained the values of $d\,(\alpha_s \sim \alpha_v)$, $d\Delta_s$, $d\Delta_v$, and $d\pi_v$ are found by the method of least squares, the resulting value of the solar parallax being

$$\pi_s + m d\pi_v \qquad (57)$$

At the time of the last transit the value of m was 0 2686 The term $\pm(mM \pm N)$ of equations (55) and (56) is to be interpreted thus —When the Sun and *Venus* are on opposite sides of the meridian it will be $+(mM+N)$· when the Sun and *Venus* are on the same side of the meridian, if the Sun is most distant from the meridian, it will be $+(mM-N)$, but if *Venus* is most distant from the meridian, then it will be $-(mM-N)$

It will not escape notice that those parts of equations (55) and (56) which correspond to $\rho_o + d\rho_o$ and $\omega_o + d\omega_o$ of the equations (54) are general for the whole Earth, and can therefore be tabulated at suitable intervals for the period of the transit, while the terms which correspond to $\rho + d\rho$ and $\omega + d\omega$ must be computed specially for each photograph.

Washington, Nov 15, 1875.

Supplementary Note on the Theory of the Horizontal Photoheliograph

Last January the Astronomer Royal did me the honour to communicate to this Society a paper of mine on the theory of the horizontal photoheliograph Since then I have continued my investigations on that subject, and have devised some improvements in the method of freeing the measures made upon the photographs from the effects of refraction. These improvements I now proceed to describe

Referring to equation (14), it is to be remarked that, if the photographs of the Sun are centred upon the measuring engine with moderate care, it will seldom happen that either δy or δx amounts to so much as $3''$, while A will usually exceed $900''$. It is therefore evident that all three of these quantities cannot be accurately derived from equations of condition of the same form as (14) without using logarithms having at least six places of decimals. As the value of A is not required, we eliminate it in the following manner In equation (14) put

$$\begin{aligned} \sin(\epsilon \mp \theta) &= \mathrm{a}, \\ n\cos(\epsilon \mp \theta) &= \mathrm{b}, \\ \tfrac{1}{2}\mathrm{R}\left[\sin^2(\epsilon \mp \theta) + n\cos^2(\epsilon \mp \theta)\right] - \frac{n\mathrm{A}^2}{2\mathrm{R}} &= \mathrm{n}, \end{aligned} \tag{58}$$

then the resulting normal equations will be

$$\begin{aligned} 0 &= [\mathrm{an}] + [\mathrm{aa}]\,\delta y + [\mathrm{ab}]\,\delta x, \\ 0 &= [\mathrm{bn}] + [\mathrm{ab}]\,\delta y + [\mathrm{bb}]\,\delta x \end{aligned} \tag{59}$$

If m is the number of equidistant points at which R is measured, the expressions for the required auxiliaries are

$$
\left.\begin{aligned}
[aa] &= \Sigma \sin^2(\epsilon \mp \theta) = \frac{1}{2} m, \\
[ab] &= n\Sigma \sin(\epsilon \mp \theta) \cos(\epsilon \mp \theta) = 0, \\
[bb] &= n^2\Sigma \cos^2(\epsilon \mp \theta) = \frac{1}{2} mn^2, \\
[an] &= \Sigma \sin(\epsilon \mp \theta)\left\{\frac{1}{2} R\,[\sin^2(\epsilon \mp \theta) + n\cos^2(\epsilon \mp \theta)] - \frac{nA^2}{2R}\right\}, \\
[bn] &= n\Sigma \cos(\epsilon \mp \theta)\left\{\frac{1}{2} R\,[\sin^2(\epsilon \mp \theta) + n\cos^2(\epsilon \mp \theta)] - \frac{nA^2}{2R}\right\}.
\end{aligned}\right\} \quad (60)
$$

As the value of $[ab]$ comes out zero, we now evidently have

$$-\delta y = \frac{[an]}{[aa]}, \qquad -\delta x = \frac{[bn]}{[bb]}. \quad (61)$$

If m is an even number there will be $\frac{1}{2}m$ pairs of values of the angle $\epsilon \mp \theta$, and in every case the two angles which compose the pair will differ from each other by 180°. If R and R′ are the radii vectores of the two points composing a pair, and if the summation is extended only through $\frac{1}{2}m$ points, then, putting

$$D = \frac{1}{2}(R - R')\left[1 + \frac{nA^2}{RR'} + (n-1)\cos^2(\epsilon \mp \theta)\right], \quad (62)$$

we have

$$
\left.\begin{aligned}
-\delta y &= \frac{2}{m} \sum_{\epsilon \mp \theta = \pi}^{\epsilon \mp \theta = 0} \sin(\epsilon \mp \theta)\, D, \\
-\delta x &= \frac{2}{mn} \sum_{\epsilon \mp \theta = \pi}^{\epsilon \mp \theta = 0} \cos(\epsilon \mp \theta)\, D
\end{aligned}\right\} \quad (63)
$$

To simplify these expressions still further, we remark that n is always very near unity, not becoming so small as 0 950 until a zenith distance of 85° is reached Assuming $n = 1$ is equivalent to supposing the apparent Sun to be replaced by an artificial one of perfectly circular outline, whose area is the same as, and whose centre coincides with the centre of figure of the apparent Sun As this assumption does not affect the values of δy and δx, we adopt it, and then equation (62) reduces to

$$D = (R - R') \quad (64)$$

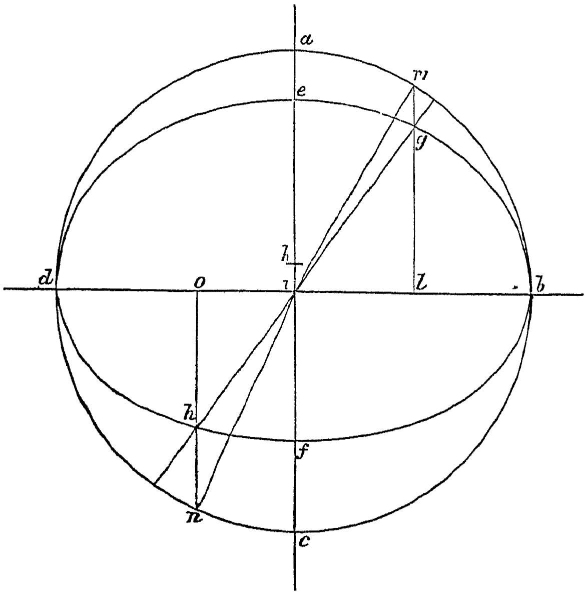
As the assumed artificial Sun is circular in form, it has no minor axis, and therefore θ may be put equal to zero, and we have finally

$$
\begin{aligned}
-\delta y &= \frac{2}{m}\sum_{\epsilon=\pi}^{\epsilon=0} \sin\epsilon\,(\mathrm{R}-\mathrm{R}'),\\
-\delta x &= \frac{2}{m}\sum_{\epsilon=\pi}^{\epsilon=0} \cos\epsilon\,(\mathrm{R}-\mathrm{R}')
\end{aligned}
\qquad (65)
$$

From these expressions the values of δy and δx can be found by means of a table of natural cosines and a Crelle's multiplication table, no logarithms being required.

As it is now evident that the assumption of an elliptical outline for the apparent Sun is unnecessary, we proceed to determine for δr a more accurate expression than equation (16) With this view, let *abcd*, Fig. 5, be the outline of the true Sun, and *i* its centre, through which the vertical circle *ac* passes; and let *ebfd* be the outline of the apparent Sun, and *k* its centre of figure Then, if *gh* is any diameter of the true Sun, taking *ac* and *bd* as a pair of rectangular axes, and putting $ai = s$, $gl = y_1$, $ho = y_2$, $aig = \theta$, $aim = \theta_1$, $ain = \theta_2$, we have

Fig 5



$$
\begin{aligned}
y_1 &= s\cos\theta_1 - s\cos\theta_1\,\frac{dr_1}{d\zeta_1},\\
y_2 &= s\cos\theta_2 - s\cos\theta_2\,\frac{dr_2}{d\zeta_2},
\end{aligned}
\qquad (66)
$$

in which $\frac{dr_1}{d\zeta_1}$ is the first derivative of the refraction, taken at a point midway between m and l; and $\frac{dr_2}{d\zeta_2}$ is the same derivative, taken at a point midway between n and o Adding these two equations, we obtain

$$y_1+y_2=s\,(\cos\theta_1+\cos\theta_2)-s\cos\theta_1\frac{dr_1}{d\zeta_1}-s\cos\theta_2\frac{dr_2}{d\zeta_2}, \tag{67}$$

and, as the factors for converting the cosines of θ_1 and θ_2 into the cosine of θ can never differ much from unity, it will be quite accurate enough to write

$$y_1+y_2=s\,(\cos\theta_1+\cos\theta_2)+s^2\cos^2\theta\frac{d^2r}{d\zeta^2}, \tag{68}$$

in which $\frac{d^2r}{d\zeta^2}$ is the second derivative of the refraction, taken at the centre of the true Sun

If we put $il=x_1$, and bear in mind that on account of refraction the horizontal diameter of the Sun is contracted by a constant ratio μ, then we have

$$x_1=\mu s\sin\theta_1, \tag{69}$$

and

$$\tan\theta=\frac{x_1}{y_1}=\tan\theta_1\frac{\mu}{1-\frac{dr_1}{d\zeta_1}}, \tag{70}$$

or

$$\tan\theta_1=\tan\theta\frac{1-\frac{dr_1}{d\zeta_1}}{\mu}, \tag{71}$$

regarding θ_1 and $\frac{dr_1}{d\zeta_1}$ as variable, and differentiating, we get

$$\frac{d\,(\tan\theta_1)}{d\zeta}=-\frac{\tan\theta}{\mu}\frac{d^2r_1}{d\zeta_1{}^2} \tag{72}$$

Assuming the well-known relations,

$$\frac{d\,(\cos\theta_1)}{d\theta_1}=-\sin\theta_1, \tag{73}$$

$$\frac{d\,(\tan\theta_1)}{d\theta_1}=\sec^2\theta_1, \tag{74}$$

dividing (73) by (74), multiplying the quotient by (72), and writing θ for θ_1, we have with sufficient accuracy

$$\frac{d\,(\cos\theta_1)}{d\zeta} = \left[\frac{\sin^2\theta\cos\theta}{\mu}\right]\frac{d^2r}{d\zeta^2} \tag{75}$$

The vertical distance between the centres of the ordinates y_1 and y_2 being very approximately $s\cos\theta$, we now have

$$s\,(\cos\theta_1+\cos\theta_2) = -\left[\frac{\sin^2\theta\cos^2\theta}{\mu}\right]s^2\frac{d^2r}{d\zeta^2}, \tag{76}$$

and therefore

$$y_1+y_2 = \left[\cos^2\theta-\frac{\sin^2\theta\cos^2\theta}{\mu}\right]s^2\frac{d^2r}{d\zeta^2} \tag{77}$$

The actual value of μ is 0·99974. Consequently it may be taken equal to unity without appreciable error, and then

$$y_1+y_2 = \cos^4\theta\; s^2\frac{d^2r}{d\zeta^2} \tag{78}$$

As y_1 and y_2 are any pair of opposite ordinates of the curve which defines the outline of the apparent Sun, and as δr is the distance ik, or, in other words, the ordinate of the centre of figure of the apparent Sun, we have, by reasoning identical with that employed in deducing equation (63),

$$\delta r = s^2\frac{d^2r}{d\zeta^2}\,\frac{2}{m}\sum_{\theta=+\frac{1}{2}\pi}^{\theta=-\frac{1}{2}\pi}\cos^4\theta, \tag{79}$$

in which m is the number of points on the Sun's limb at which ordinates have been computed. If we assume these points to be equidistant upon the apparent Sun, and take $m=12$, as in the measurements of the photographs, then

$$\delta r = 0·375\, s^2\frac{d^2r}{d\zeta^2} \tag{80}$$

To test the amount of inaccuracy introduced in equation (79) by writing θ for θ_1 in (75) and omitting μ in (78), the rigorous expression for δr, involving θ, θ_1, and μ, was formed; and upon substituting in it the numerical values of these quantities for the extreme case where the Sun has a zenith distance of eighty degrees, the numerical coefficient in (80) became 0·374

This differs so little from the value before found as to lead to the conclusion that equation (79) is probably as accurate as the refraction tables themselves.

We have thus found the values of δy, δx, and δr, and it only remains to deduce from them the expressions for $R \sin \varepsilon$ and $R \cos \varepsilon$, R and ε being respectively the radius vector and angle of the image of the true Sun's centre, referred to the original system of polar coordinates given by the measuring engine An inspection of Fig 4 shows that δr is measured along the line $S'_* v'$, while δy and δx are measured along lines respectively parallel and perpendicular to $S'_* Z$ Hence, as the angle ε is measured from a line at right angles to $S'_* Z$, and $\theta_\odot$ is the angle ZS'_*S',

$$\begin{aligned} R \sin \varepsilon &= \delta y + \delta r \cos \theta_\odot, \\ R \cos \varepsilon &= \delta x \mp \delta r \sin \theta_\odot, \end{aligned} \tag{81}$$

in which δr must be regarded as essentially negative, $\theta_\odot$ must always be taken less than ninety degrees, and the double sign must be understood in the same way as in the equations (10) It is perhaps scarcely necessary to add that these are the values of $R \sin \varepsilon$ and $R \cos \varepsilon$ which must be employed in the equations (18)

To facilitate the computation of δr from equation (80), it is desirable to have a table giving the numerical values of the second derivative of the refraction To form such a table we assume Bessel's expression for the refraction, namely,

$$r = \alpha \tan \zeta, \tag{82}$$

where r is the refraction, expressed in seconds of arc, and α is a quantity which varies slowly with the zenith distance ζ The first derivative of this expression is

$$\frac{dr}{d\zeta} = \frac{1}{\cos^2 \zeta}\left[\alpha + \tan \zeta \cos^2 \zeta \frac{d\alpha}{d\zeta}\right], \tag{83}$$

which becomes

$$\frac{dr}{d\zeta} = \frac{1}{\cos^2 \zeta} \alpha', \tag{84}$$

by putting

$$\alpha' = \alpha \operatorname{arc} 1'' + \tan \zeta \cos^2 \zeta \frac{d\alpha}{d\zeta} \tag{85}$$

Differentiating (84), we get

$$\frac{d^2r}{d\zeta^2}=\frac{2\tan\zeta}{\cos^2\zeta}\left[\alpha'+\frac{1}{2}\cot\zeta\,\frac{d\alpha'}{d\zeta}\right], \tag{86}$$

which becomes

$$\frac{d^2r}{d\zeta^2}=\frac{2\tan\zeta}{\cos^2\zeta}\,\alpha'' \tag{87}$$

by putting

$$\alpha''=\alpha'\,\mathrm{arc}\,1''+\frac{1}{2}\cot\zeta\,\frac{d\alpha'}{d\zeta} \tag{88}$$

The factor arc 1'' is introduced in equations (85) and (88) because in (82) α is expressed in seconds of arc, while α' and α'' must be expressed in parts of radius. Bessel has given a table of the values of α', which may be found in his *Astronomische Untersuchungen*, vol. 1, pp. 198 and 199, and also in Chauvenet's *Spherical and Practical Astronomy*, pp. 572 and 573, but it must be noted that our α' is Bessel's α''. From the differences of consecutive values of α' given in that table, the values of $\frac{d\alpha'}{d\zeta}$ have been obtained, and then the values of α'', given below, were computed by means of equation (88).

The quantities in the following table correspond to a state of the atmosphere such that the barometer would stand at 29.597 inches, its attached thermometer at 32° F., and the external thermometer at 48°.75 F. The first and fourth columns of the table contain the argument. The second and fifth columns contain the values of log α'', to the argument true zenith distance, computed by means of equation (88), but it must be carefully noted that in using these logarithms their characteristics must be diminished by 10. The third and sixth columns contain the values of δr, to the argument true zenith distance, computed by means of equation (80); and the seventh column, headed $\delta r'$, contains the values of δr to the argument apparent zenith distance, for all cases where they differ sensibly from the values given in the sixth column.

Strictly speaking, α'', δr, and $\delta r'$ are functions, not only of the zenith distance, but also of the density of the atmosphere, but so long as the temperature of the latter remains between +30° and +75° F., and its pressure between 29 and 30 inches of mercury, the values of δr and $\delta r'$ given in the table will not be in error more than 0''.01 for any zenith distance less than 80°. For temperatures, pressures, or zenith distances beyond these limits, if great accuracy is desired, the values of α'', δr, and $\delta r'$ must be multiplied by the factor $\beta^{A''}\gamma^{\lambda''}$, in which $\beta = BT$, and the values of A'', λ'', B, T, and γ are to be taken from Bessel's Table, cited above. To prevent misapprehension, it may be well to note that the values of A'' and λ'' given by Bessel apply rigorously only to the first derivative of the refraction, but their use with the second derivative gives rise to so little error that it does not seem worth while to recompute them specially for it.

ζ	log α'	δr	ζ	log α''	δr	$\delta r'$
°		″	°		″	″
0	1 1314	0 000	52	1 1238	0 003	
4	1289	000	54	1229	004	
8	1286	000	56	1218	004	
10	1286	000	58	1205	005	
12	1286	000	60	1190	006	
16	1286	000	62	1173	008	
20	1285	000	64	1147	010	
24	1284	001	66	1118	012	
28	1283	001	68	1080	016	
30	1282	001	70	1034	021	
32	1281	001	72	0972	029	0 029
34	1280	001	74	0887	040	040
36	1279	001	76	0776	058	059
38	1278	001	78	0605	089	090
40	1274	001	80	0310	144	147
42	1270	002	81	1 0107	188	193
44	1265	002	82	0 9858	253	261
46	1259	002	83	9504	349	363
48	1252	002	84	8991	491	517
50	1 1246	0 003	85	0 8431	0 747	0 809

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V *The Sidereal System.* By MAXWELL HALL, M.A, of Pemb. Coll Camb.

(*Communicated by Sir G B. Airy*)

INTRODUCTORY REMARKS.

IN the following Memoir it is my intention to bring forward a theory of the greatest importance to Sidereal Astronomy, which connects the motion of the Solar System through space with the proper motions of several of the so-called Fixed Stars, and which binds them together in one Dynamical System, the Sun and stars are thus subject to the same law of Force, and revolve in immense orbits round the same centre, Proper Motion is connected with Parallax, and both with that radial velocity which Dr HUGGINS has lately made known to us by means of the spectroscope.

But finding that I am unable to do full justice to the work thus taken in hand, I would here excuse myself by stating under what circumstances the Memoir was written It was commenced in the year 1869, when I was studying at Cambridge, but no progress was made until I had taken my degree in 1871, when the system was fairly sketched out But one of the most important stars, *Sirius*, had given me great trouble, the formulæ gave a negative value to the parallax, and thus prevented a comparison of the observed with the computed radial velocity, and by no adjustment of the system was I then able to include that star This was the more annoying, because at that time it was the only star which Dr HUGGINS had observed with the spectroscope for velocity in the line of sight.

It thus became necessary to delay the publication of the theory, but in the meantime, bad health obliged me to leave England, and it was in this magnificent climate, among the mountains of Jamaica, that I heard that Dr HUGGINS had confirmed the theory as far as several other important stars were concerned. Since that time much trouble has been taken to improve the System as far as possible, and now publication is necessary for its further progress; the proper motions, observed parallaxes, and radial velocities of several of the stars require confirmation, and without such aid I can do little or nothing more But at some future time, and with improved data, I may hope to be able to treat the subject more rigorously and more concisely, the present Memoir was written in sections at different times, when any steps were made in advance, and its form has been retained lest any confusion should arise by omitting some steps and blending others together

THE SIDEREAL SYSTEM.

THE theory of the motion of the Solar System through space has been examined by investigations more or less rigorous, and the results are so far in accordance as to declare the truth of that motion, and to determine with considerable accuracy the point towards which the system moves, it is here sufficient to say that the investigations are all based upon the general but very minute tendency of the stars to disperse in all directions from that point in the celestial sphere towards which the Solar System moves, and to crowd together towards that point from which the system moves, not that the proper motions of the stars are entirely due to this motion of the Solar System, for, on the contrary, they apparently move in all directions with very different angular velocities, but still there is a certain tendency, or average motion of the stars collectively, which led Sir WILLIAM HERSCHEL, in the year 1783, to announce the translation of the Solar System through space, and which has been repeatedly confirmed by several mathematicians

The next stage in the progress of the theory introduces us to such subjects as the position of the centre of this motion, and the law of force which this motion obeys, for, reasoning by analogy, we can only suppose that the Sun moves in an orbit about some point in space, material or immaterial, in motion or at rest

Again, whatever may be the attracting power, if sufficiently great to retain the Sun in an orbit, it must have the same effect on the neighbouring stars, so that the Sun and the nearer stars must move in orbits about the same point, the centre of the Sidereal System We shall assume the truth of this argument, and proceed to search for the centre in the following manner

Let the centre of the Sun be taken as the origin of one set of rectangular coordinates, the axis of x being drawn to the First Point of *Aries*, the axis of y to that point on the celestial Equator whose Right Ascension is 90°, and the axis of z perpendicular to the two former, and towards the northern Pole; let all variable quantities be reduced to the epoch Jan 1 0, 1850, and take one year as the unit of time, and the mean radius of the Earth's annual orbit as the unit of space

Let θ, ϕ, and ρ be the heliocentric polar coordinates of a star, and let l, m, and n be the direction-cosines of ρ, so that

$$l = \sin\theta\cos\phi,$$
$$m = \sin\theta\sin\phi,$$
$$n = \cos\theta$$

Then, by transferring the origin to the centre of the Sidereal System, if X, Y, and Z are the coordinates of the Sun, and x, y, and z those of the star, we get

$$x = X + l\rho,$$
$$y = Y + m\rho,$$
$$z = Z + n\rho,$$

where of course the axes remain parallel to their former directions

By differentiating these last equations with respect to t, the time, we have

$$\frac{dx}{dt} = \frac{dX}{dt} + l\frac{d\rho}{dt} + \rho\frac{dl}{dt},$$
$$\frac{dy}{dt} = \frac{dY}{dt} + m\frac{d\rho}{dt} + \rho\frac{dm}{dt},$$
$$\frac{dz}{dt} = \frac{dZ}{dt} + n\frac{d\rho}{dt} + \rho\frac{dn}{dt},$$

and if r be the distance of the star from the centre, and v the velocity of the star in its orbit,

$$r^2 = x^2 + y^2 + z^2,$$

$$v^2 = \left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2.$$

In the above equations $\frac{dX}{dt}$, $\frac{dY}{dt}$, and $\frac{dZ}{dt}$ are the velocities of the Sun along the axes, and are therefore approximately known; and also, in the case of those few stars whose annual parallaxes have been found by observation, ρ is known, but $\frac{d\rho}{dt}$, or the velocity with which the Sun and any star approach or recede from each other, must be considered as unknown; and we shall only employ the radial velocities found by the spectroscope as supplementary, but very important, tests of the truth of our theoretical results Therefore another equation is required in order to eliminate $\frac{d\rho}{dt}$, and then r and v could be expressed in terms of X, Y, and Z and known quantities; but here again another difficulty presents itself, because it is only in circular orbits that there are equations between v, r, and quantities which are constant for the whole system, and thus, while we can allow the Sun to move in an elliptical orbit, it is necessary to assume that the stellar orbits are circular, for otherwise each star would introduce an unknown quantity, namely, the semi-axis major of its orbit; however, since this restriction will give us the equation required for $\frac{d\rho}{dt}$, it removes at once two insurmountable difficulties.

Assuming, therefore, that the stellar orbits are circular, we have

$$v^2 = r\,\psi(f, r),$$

where $\psi(f, r)$, the acceleration, is some function of r and of quantities which are constant for the whole system. Thus, if the Sun and the nearer stars revolve about some gigantic central body whose mass was f, we should have $v^2 = \frac{f}{r}$, and $v^2 r$ would be constant for all the members, again, if the Sun and stars revolve about their common centre of gravity, we should have $v^2 = fr^2$, and in this case $\frac{v^2}{r^2}$ would be constant, while f would be the star-density of space, or at least depend upon that density; and though the latter hypothesis is the more probable, yet it will be necessary to retain the equation in its general form Again, since the stellar orbits are assumed to be circular, we have $\frac{dr}{dt}=0$, or

$$x\frac{dx}{dt}+y\frac{dy}{dt}+z\frac{dz}{dt}=0$$

The above equations contain the solution of the restricted problem, and it now becomes necessary to put them in more convenient forms. Let V be the velocity of the Sun, let α and β be the Right Ascension and North Polar Distance of the solar *apex*, or the point towards which the Sun moves; and let

$$\begin{aligned}\lambda &= \sin\beta\cos\alpha,\\ \mu &= \sin\beta\sin\alpha,\\ \nu &= \cos\beta,\end{aligned}$$

then

$$\frac{dX}{dt}=\lambda V,\quad \frac{dY}{dt}=\mu V,\quad \text{and}\quad \frac{dZ}{dt}=\nu V$$

Again

$$\begin{aligned}\frac{dl}{dt} &= n\cos\phi\frac{d\theta}{dt}-m\frac{d\phi}{dt},\\ \frac{dm}{dt} &= n\sin\phi\frac{d\theta}{dt}+l\frac{d\phi}{dt},\\ \frac{dn}{dt} &= -\sin\theta\frac{d\theta}{dt}\end{aligned}$$

But if $\delta\phi$ and $\delta\theta$ are the annual proper motions of a star in Right Ascension and North Polar Distance expressed in seconds of arc, $\frac{d\phi}{dt}=\delta\phi\sin 1''$, and $\frac{d\theta}{dt}=\delta\theta\sin 1''$; now put $\frac{dl}{dt}=\delta l\sin 1''$, $\frac{dm}{dt}=\delta m\sin 1''$, and $\frac{dn}{dt}=\delta n\sin 1''$, so that

$$\begin{aligned}\delta l &= n\cos\phi\,\delta\theta-m\delta\phi,\\ \delta m &= n\sin\phi\,\delta\theta+l\delta\phi,\\ \delta n &= -\sin\theta\,\delta\theta,\end{aligned}$$

and the numerical values of δl, δm, and δn may be very easily obtained from the annual proper motions

The velocities of a star along the axes may now be expressed in the following manner.

$$\frac{dx}{dt}=\lambda V+l\frac{d\rho}{dt}+\rho\sin 1''\,\delta l,$$

$$\frac{dy}{dt}=\mu V+m\frac{d\rho}{dt}+\rho\sin 1''\,\delta m,$$

$$\frac{dz}{dt}=\nu V+n\frac{d\rho}{dt}+\rho\sin 1''\,\delta n$$

We shall replace the factor sin 1″ by the suffix $({}_o)$, so that ρ_o is equivalent to $\rho\sin 1''$, or the unit of space in quantities thus marked is the distance of a star whose annual parallax is one second of arc This unit of space may be termed the *sidereal* unit; it is intimately connected with parallax, for if ϖ be the annual parallax of a star in seconds of arc,

$$\varpi\rho_o=1,$$

so that $\rho_o=\frac{1}{\varpi}$, or $\varpi=\frac{1}{\rho_o}$; in numbers, it is 206,265 times the mean radius of the Earth's annual orbit. The unit of space hitherto proposed to avoid large numbers in sidereal measurements is the distance light travels in the course of a year, but such an unit would only add confusion to our equations, and hence it becomes necessary to adopt another. But for velocities we shall still retain the former unit, the mean radius of the Earth's orbit, and thus avoid very large or very small numbers

After this important change it will be advisable to write down the principal equations again, they are

$$\left.\begin{aligned}x_o&=X_o+l\rho_o,\\ y_o&=Y_o+m\rho_o,\\ z_o&=Z_o+n\rho_o,\end{aligned}\right\}\qquad(1)$$

$$\left.\begin{aligned}\frac{dx}{dt}&=\lambda V+l\frac{d\rho}{dt}+\rho_o\delta l,\\ \frac{dy}{dt}&=\mu V+m\frac{d\rho}{dt}+\rho_o\delta m,\\ \frac{dz}{dt}&=\nu V+n\frac{d\rho}{dt}+\rho_o\delta n;\end{aligned}\right\}\qquad(2)$$

$$x_o\frac{dx}{dt}+y_o\frac{dy}{dt}+z_o\frac{dz}{dt}=0,\qquad(3)$$

$$v^2=r_o\psi(F,r_o),\qquad(4)$$

where F has been taken instead of f in order to show the change of the unit, a matter of no importance until we come to discuss f itself. And also there are the two equations :

$$r_o^2 = x_o^2 + y_o^2 + z_o^2, \tag{5}$$

$$v^2 = \left(\frac{dx}{dt}\right)^2 + \left(\frac{dy}{dt}\right)^2 + \left(\frac{dz}{dt}\right)^2 \tag{6}$$

Again, let Æ and Δ be the Right Ascension and North Polar Distance of the Sun when seen from the centre, let R_o be its distance from the centre, and let L, M, and N be the direction-cosines of R_o, so that

$$\begin{aligned} L &= \sin\Delta\cos \text{Æ}, \\ M &= \sin\Delta\sin \text{Æ}, \\ N &= \cos\Delta, \end{aligned}$$

and then

$$X_o = LR_o, \quad Y_o = MR_o, \quad Z_o = NR_o$$

Let

$$H = lL + mM + nN,$$

then, from (1) and (5),

$$r_o^2 = R_o^2 + \rho_o^2 + 2HR_o\rho_o \tag{I}$$

Let

$$\begin{aligned} a &= l\lambda + m\mu + n\nu, \\ b &= \lambda\delta l + \mu\delta m + \nu\delta n, \\ c^2 &= \delta l^2 + \delta m^2 + \delta n^2, \end{aligned}$$

then, from (2) and (6),

$$v^2 = V^2 + \left(\frac{d\rho}{dt}\right)^2 + 2V\left(a\frac{d\rho}{dt} + b\rho_o\right) + c^2\rho_o^2, \tag{II}$$

remembering that

$$l\delta l + m\delta m + n\delta n = 0$$

And from (1), (2), and (3), by putting

$$\begin{aligned} K &= L\delta l + M\delta m + N\delta n, \\ \Gamma &= L\lambda + M\mu + N\nu, \\ H &= \frac{1}{R_o}, \end{aligned}$$

so that Π is the annual parallax of the centre if it could be observed, we have

$$\frac{d\rho}{dt}(\mathrm{II}+\Pi\rho_0)+\mathrm{K}\rho_0+a\rho_0\Pi \mathrm{V}+\Gamma \mathrm{V}=0 \qquad \text{(III)}$$

It will be noticed that, by substituting the value of $\frac{d\rho}{dt}$ from (III) in (II), $\frac{d\rho}{dt}$ will be eliminated, the necessity of which has been already pointed out; but the equations are more convenient in their present form It will also be noticed that, by substituting from (I) and (II) in (4), there will remain one equation containing an unknown function of the four unknown quantities, Æ, Δ, R_0, and V, but, as they are all common to the assumed system, it will be possible to determine them by employing those stars whose parallaxes have been found by observation. With regard to V, it was said before that the velocity of the Sun was known, but that V is not known with sufficient accuracy for our purpose will appear from what immediately follows

The mean of the results obtained by MM Argelander, Lundahl, and Otto Struve indicates the position of the solar apex to be

	°	′	
R A	259	9	(i)
N P D	55	23	

for the beginning of the year 1790; while, from southern stars not employed in the above calculations, Mr Galloway found its position for the same epoch to be

	°	′	
R A	260	1	(ii)
N P D	55	37	

In vol xxviii of the *Memoirs of the Royal Astronomical Society,* Professor Airy conducts the inquiry upon two suppositions, the first assumes the irregularities of proper motion to be due to errors of observation, while the second supposes them to be due to their actual motions. The results are, for the beginning of the year 1840,

	°	′	
R A	256	54	First Supposition,
N P D	50	31	

	°	′	
R A	261	29	Second Supposition,
N P D	65	16	

and we cannot do better than take the mean of these positions, which is

	°	′	
R A	259	12	
N P D	57	54	(iii)

In these calculations the stars which were employed had large proper motions, and were therefore but few in number, two or three hundred at most, but where two or three thousand stars are employed, as in the investigations of M. MADLER and Mr. DUNKIN, most of them must have very small proper motions, and errors of observation must have great effect, so that it is probable that the First Supposition will prove the more correct of the two; and this is actually found to be the case, for Mr DUNKIN, in vol xxxii, employed a large number of stars in the same formulæ which Professor AIRY used, and the results on the First Supposition are nearly the means of (i), (ii), and (iii), while those on the Second Supposition differ considerably We shall therefore bring (i), (ii), and (iii), up to the year 1850 by applying the proper precessions, and take the mean as the most probable position of the solar apex.

	Precession in R A	Precession in N P D
(i)	+32′	+ 4′
(ii)	+32	+ 3
(iii)	+ 6	+ 1

	R A 1850		N P D 1850	
	°	′	°	′
(i)	259	41	55	27
(ii)	260	33	55	40
(iii)	259	18	57	55
	α = 259	51	β = 56	21

But the value of V cannot be found with the same accuracy as α and β, because the distances of the stars have much greater effect upon the result, and these distances, with a few exceptions, are unknown. Thus, if all the stars were at the same distance from the Sun, α and β would be independent of that distance; and this reasoning applies to a certain extent when the distances of the stars are supposed to be functions of their magnitudes.

The results, however, are these; the angular velocity of the Sun, as seen from an average first-magnitude star at right angles to the direction of the motion, is 0″·33, according to Mr. Dunkin, on the First Supposition, and this closely agrees with the angular velocity found by M. Otto Struve. But the mean of the angular velocities found by Professor Airy is as large as 1″·6; and if the parallax of an average first-magnitude star is 0″·2, V is 8, or in a year the Sun passes over a space equal to eight radii of the Earth's orbit. But, in consequence of this disagreement, we must suppose that V is unknown at present, and afterwards we shall compare our determination with that of Professor Airy.

In beginning to search for the centre, the *Pleiades* first claim our attention, a group of stars towards which M. Madler has turned the whole of the interest attached to the present subject. He was led to the conclusion that the centre probably lay out in that direction by noticing that several stars in that part of the heavens apparently move together, indicating the presence of some controlling power; and then the centre of gravity of the *Pleiades* must be a centre of force, to the stars composing that group at any rate; and so he was led to consider *Alcyone*, the brightest star in the group, as the centre of the Sun's motion through space. But Mr. Proctor has lately called attention to the fact that there are other parts of the heavens where there is a community of motion, and he prefers the constellation of *Perseus*, already marked as the choice of M. Argelander; and then the clustering of the stars about the Sword-hand, which is in the plane of the Galaxy, and which is also 90° from the solar apex, will indicate the position of the centre in that constellation.

However, let us assume that *Alcyone* is the centre of the system; then Æ and Δ will be the Right Ascension and North Polar Distance of the point diametrically opposite to this star, whence L, M, and N; and assuming certain values of V and R_0, we get the corresponding values of v and r_0 for five or six of those stars whose parallaxes and proper motions have been tolerably well ascertained. We must then seek for an equation between v and r_0, beginning with the two already pointed out, namely $v^2 = \frac{F}{r_0}$ and $v^2 = Fr_0^2$; but failing to find such an equation between v and r_0, we must alter V, and so obtain another series, but as V lies between certain limits, by taking the extreme and mean values, namely, 2, 5, and 8, we shall sufficiently test the assumed value of R_o, the distance of *Alcyone*, then R_o must be changed and the whole process repeated

It was found that neither *Alcyone* nor yet the Sword-hand in *Perseus* is the centre required, and a general examination of the whole heavens became necessary

My examination was not very complete, because it was both laborious and discouraging; the brightest stars, the larger groups, and the vast congregation of nebulæ in *Virgo*, all failed me, as a last resource I examined about twenty points at equal distances from each other on the great circle whose pole is the solar apex, and found, not one, but *two* points which gave satisfactory results, one in *Andromeda*, and the other diametrically opposite, in *Hydra*, below *Corvus*, and for either point R_o was large, and V not less than 8; but no numerical value could be given to R_o, for it was sufficient to put $\Pi = 0$, when of course the stars would all be at an infinite distance from the centre, equation (I) therefore failed, but equations (II) and (III) made all the velocities tolerably equal to V.

It would therefore appear that the centre lies upon the line passing through the Sun and these two parts of the heavens, and that it is at such a great distance that the Sun and the nearer stars move about it with almost the same velocity; for in the equation $v^2 = r_o\psi(F, r_o)$, if r_o be so large that it may be considered constant for these members of the system, it follows that v^2 must also be considered constant

Another important conclusion to be drawn is that the solar orbit must be nearly circular as well as the stellar orbits, so that, without fear of any great error, we may put $\Gamma = 0$; and the former equations must now be modified so as to suit the general ideas we have gained

Let

$$P = \frac{L}{N}, \quad Q = \frac{M}{N},$$

then

$$\lambda P + \mu Q + \nu = 0$$

Put Γ and Π each equal to zero in (III), and let

$$u = \frac{K}{\Pi} = \frac{P\delta l + Q\delta m + \delta n}{lP + mQ + n}, \qquad (7)$$

then (III) reduces to $\frac{d\rho}{dt}+u\rho_0=0$, and by putting $v^2=V^2$ in (II), we get

$$\left(\frac{d\rho}{dt}\right)^2+2V\left(a\frac{d\rho}{dt}+b\rho_0\right)+c^2\rho_0{}^2=0,$$

and replacing $\frac{d\rho}{dt}$ by $-u\rho_0$, we have

$$\rho_0\,(c^2+u^2)-2V\,(au-b)=0,$$

whence

$$\varpi=\frac{c^2+u^2}{2V\,(au-b)} \qquad (8)$$

When P, Q, and V are known, ϖ may therefore be easily determined for any star by means of equations (7) and (8), but at present the problem still retains the inverse form, and P, Q, and V must be found from those stars whose parallaxes have been observed At first I attempted to obtain them by assuming rough values, introducing corrections, forming several equations of condition, and solving them by the method of Least Squares; but the equations failed because the corrections were so large that their squares and products could not be neglected

I then adopted another plan, and found the values of P and V by means of the two stars *α Centauri* and 61 *Cygni*, the only stars whose parallaxes could be depended on. The parallax of *α Centauri* was taken to be 0″ 936, which is the mean of three separate determinations*, that of 61 *Cygni* was taken to be 0″ 422, which is the mean of four separate determinations†, the proper motions of 61 *Cygni* were taken from Mr Main's Paper in vol xix of the *Memoirs of the Royal Astronomical Society*, but the proper motions of *α Centauri* I was obliged to determine myself When two stars form a Binary System, we require the proper motions of the centre of gravity of that system, and assuming that the centre of gravity lies midway between the two components, α^1 and α^2, I found the proper motions of *α Centauri* to be -0^s 471 in R A, and 0″ 78 in N.P D, by comparing the observations of Lacaille at the Cape of Good Hope, reduced to the year 1750, with the modern observations of Mr. Ellery in Australia in the year 1868. In order to show how P and V were obtained from these stars, *α Centauri* gave the equation

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* 0″ 976 Henderson, corrected by Peters, 0″ 913 Maclear, first series, 0″ 919 Maclear, second series, and the probable error of the mean is ±0″ 014

† 0″ 374 Bessel, corrected by Peters, 0″ 349 Peters, 0″ 564 Auwers, 0″ 402 Johnson, and the probable error of the mean is ±0″ 032

$$c^2+u^2 = 2\varpi V\,(au-b)\,;$$

and 61 *Cygni* gave the similar equation

$$c'^2+u'^2 = 2\varpi' V\,(a'u'-b')\,,$$

and eliminating 2V,

$$\varpi'(a'u'-b')\,(c^2+u^2) = \varpi\,(au-b)\,(c'^2+u'^2)$$

Then u and u' were expressed in terms of P and Q, and Q was eliminated by means of the equation

$$\lambda P+\mu Q+\nu = 0$$

The resulting equation for P was therefore of the fourth degree; but there was no difficulty about the roots, for two of them were impossible, and one of the possible roots made V so absurdly large that it was at once rejected; and the last root gave

$$\begin{aligned} P &= +1\ 862 \\ Q &= +0\ 343 \\ V &= \ \ 9\ 9475 \end{aligned}$$

We now proceed to calculate the parallaxes of a few stars by means of their proper motions and the foregoing equations, in order to test the truth of our theory by comparing the results with those of observation

ARCTURUS

The proper motions of this star are $-0^{s}\,079$ in R.A. and $+1''\,93$ in N P D , so that $\delta\theta = +1\ 93$, and $\delta\phi = -1\ 185$, whence ϖ, the annual parallax, is equal to $0''\,20$, and since Dr Peters found it to be $0''\,127$ by observation, the difference is only $0''\,07$, and the first result may be considered satisfactory

Again, it will be found that $\frac{d\rho}{dt}$ is $-14\ 6$, or that the distance between the Sun and *Arcturus* is diminishing at the rate of 14 6 radii of the Earth's orbit per annum, and we are now able to refer to the observations of Dr HUGGINS, which were made expressly to determine such velocities His researches are so well known, that it is sufficient to say that these radial velocities, or velocities along the line of sight, will produce a change in the refrangibility of light, and a corresponding change in the position of the dark lines in the spectrum, and that these latter changes have been measured, indicating different radial velocities for different stars

It so happens that *Arcturus* has the largest radial velocity measured by Dr HUGGINS, and he found that the distance between the Sun and *Arcturus* is diminishing at the rate of 55 miles per second, or, in terms of our units,* at the rate of 19·0 radii of the Earth's orbit per annum

Nothing could be more satisfactory than the agreement between theory and observation in the case of *Arcturus*, always remembering that the theory is in a rough and general form, and that considerable uncertainty attends all observed parallaxes and radial velocities

VEGA.

For this star $\varpi = 0'' 06$; $\frac{d\rho}{dt} = -18{\cdot}6$. Now Dr HUGGINS found that $\frac{d\rho}{dt}$ is between -15 and -19, and this has been confirmed by Dr VOGEL, who found $-17{\cdot}9$, the theoretical radial velocity is therefore highly satisfactory

With regard to the parallax, M STRUVE's earlier observations made it between 0″ 07 and 0″ 18, but subsequent observations, and other observers, have made it greater Now, Professor AIRY made a most rigorous investigation of the parallax of this star (*Memoirs of the Royal Astronomical Society*, vol x), with the TROUGHTON Circle at Greenwich he found +0″ 2236, but with the JONES Circle he found −0″ 1015, so that, if all the observations had been combined, the resulting parallax would have been about 0″ 06; and taking 0″ 12 as the result of M STRUVE's earlier observations, the mean, 0″ 09, will be the probable parallax of this star, which agrees very closely with the theoretical value

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* In order to reduce miles per second to radii of the Earth's orbit per annum we must divide by 2 9

PROCYON.

The proper motions of this star are subject to small variations, which Dr AUWERS has explained in a most satisfactory manner by supposing the bright star to revolve about a dark one in its immediate vicinity; but since the period is small, it follows that the proper motions of the centre of gravity of this Binary System can be determined from observations differing considerably in time, Mr MAIN found them to be $-0^s.048$ in R.A., and $+1''.08$ in N.P.D.

Whence $\varpi = 0''.08$, $\frac{d\rho}{dt} = +8.9$, but the parallax found by Dr. AUWERS is $0''.123$, so that the difference is small, only about $0''.04$

Now it happens that, as the binary orbit of the bright star is perpendicular to the line of sight, the spectrum will not be affected by this orbital motion, and while Dr HUGGINS found $\frac{d\rho}{dt}$ to be small and positive, Dr VOGEL found it to be as large as 21, hence we may conclude that $\frac{d\rho}{dt}$ will prove to be about $+12$ from future observations.

CAPELLA

For this star $\varpi = 0''.02$, $\frac{d\rho}{dt} = +6.8$; and, since Dr PETERS found the parallax to be $0''.046$, the difference is remarkably small.

Dr HUGGINS was not able to give a numerical value to the radial velocity, but he found it to be small and positive; the results for *Capella* are therefore satisfactory

ALTAIR.

In this case $\varpi = 0''.14$, $\frac{d\rho}{dt} = -14.3$. Dr. VOGEL found the radial velocity to be -16.5,[*] which is very satisfactory, but, as far as I am aware, the parallax has generally been supposed to be insensible The only results I have seen are those of M STRUVE, given in *Memoirs of the Royal Astronomical Society*, vol xii, indicating a parallax of 0″ 181, supposing the parallaxes of the comparison stars, β and γ *Aquilæ*, to be insensible, but the parallax of γ is really insensible, according to theory, that of β cannot be found at present; and therefore it is probable that 0″·181 is the absolute parallax of *Altair*

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[*] At Greenwich -10 was found, the mean is -13.3

70 *p* OPHIUCHI

By employing the proper motions given in the *British Association Catalogue*, we shall find the parallax to be 0″ 12, while 0″ 16 was found by M KRUGER a very close agreement The star is between the fourth and fifth magnitudes, and of course has not yet been observed with the spectroscope

21258 LALANDE.

Mr LYNN, of the Greenwich Observatory, has given the proper motions of this very small star, they are $-0^s\,386$ in R A, and $+1''\,36$ in N.P D The resulting parallax is 0″ 31, M KRUGER found 0″·26; so that, when this star and 70 *p Ophiuchi* are considered together, it is evident that M KRUGER's observations are of the very highest order and quality

34 GROOMBRIDGE

In vol xxviii p 97 of the *Monthly Notices of the Royal Astronomical Society* will be found a brief account of the determination of the parallax of this star by Dr AUWERS; it is as large as 0″ 307, and as I was anxious to confirm this important result, I lately communicated with the Editor of *Nature*, who kindly furnished me with the following position and proper motions.—

R A 1850	0^h	9^m	$51^s\,75$
Proper Motion in R A			$+0^s\,2551$
N P D 1850	46°	49′	38″ 1
Proper Motion in N P D			$-0''\,366$,

and the resulting parallax is 0″·19, the agreement here is not very close, but still the fact of a sensible parallax is confirmed.

POLARIS

is the last star we shall refer to among those which have given satisfactory results; 0″·067 is the parallax found by Dr Peters, our theory makes it quite insensible by placing it at the enormous distance of 490 sidereal units, and it will be advisable to dismiss this star for the present until the theory is more fully developed.

There can thus be no doubt that the ten following stars are members of the same Dynamical System, together with the Sun, they are

α Centauri
61 Cygni
Arcturus
Vega
Procyon
Capella
Altair
70 *p* Ophiuchi
21258 Lalande
34 Groombridge,

and they have confirmed the adopted values of P, Q, and V; but there still remain five stars whose parallaxes have been ascertained, they are

Sirius
1830 Groombridge
σ Draconis
ι Ursæ Majoris
17415 Oeltzen,

and these five give erroneous results. The first and the last have *negative* parallaxes from the preceding formulæ, the others are positive, but far too large. Five out of fifteen or sixteen is a large proportion, and it is particularly annoying that *Sirius* is among the number.

Omitting the stars *Altair* and 34 Groombridge, this was the stage in the theory arrived at in the year 1871, as already mentioned in the Introductory Remarks; since then, the spectroscope has confirmed several of the radial velocities; and as those negative parallaxes may be due to the imperfect state of the theory in its present form, it becomes necessary to *correct* it as far as we may be able.

Let S be the Sun, A   *a* S *b*   · B, and ASB the line on which the centre lies, but we do not yet know whether it lies in the direction SA or SB, but in either case it is at such a distance that the Sun and any stars a, b near the sun, revolve about the centre with almost the same velocity Now suppose, from a *general* examination of observed parallaxes and radial velocities, it is found that the stars about a have on the whole a larger velocity than the stars about b; then the centre will lie in the direction SA if $v^2 = \frac{F}{r_o}$, but it will lie in the direction SB if $v^2 = Fr_o^2$, and therefore a general examination may fail to advance the theory a step further

Thus, by employing observed parallaxes and radial velocities in equation (II), it will be found that the velocities of

Vega,
Altair,
The Sun,
and Arcturus

are all in order of magnitude, increasing from *Vega* to *Arcturus*; and if the centre lies towards *Andromeda* and at a considerable distance, 100 units for instance, it will be found that their distances from the centre are also in increasing order of magnitude, so that probably they will all revolve about a centre of gravity according to the equation $v^2 = Fr_o^2$ But if the centre lies towards *Hydra*, the distances are in decreasing order, and then they must revolve about some gigantic central mass according to the equation $v^2 = \frac{F}{r_o}$; and it is necessary to decide between the two before we can proceed with the corrections.

Now there are three circumstances to guide us, all of which point to the former hypothesis. The first is that there is no visible centre, and no clustering of the stars about it; while, on the other hand, there are innumerable clusters of stars in the heavens which are apparently bound together by their mutual gravitation, so that analogy would lead us to choose the equation $v^2 = Fr_o^2$. The second is that the velocities increase from *Vega* to *Arcturus* with very great rapidity; this we infer is chiefly the fault of observation, as but small changes in the parallaxes are required to reduce them all to V, the velocity of the Sun, but still it would be preferable to choose the equation $v^2 = Fr_o^2$ again, were it only to reduce the residual errors or differences, for by this equation the velocities will increase outwards with much greater rapidity than they would increase inwards by the other.

The last circumstance is rather remarkable; it will be remembered that $L = \sin\Delta\cos Æ$, $M = \sin\Delta\sin Æ$, and $N = \cos\Delta$, also that $L = PN$, $M = QN$, so that the two values of Æ and Δ are known. But it so happens that L, M, and N have all the same sign; they are all negative if the centre lies towards *Andromeda*, and all positive if it lies towards *Hydra*. Now, turning to equation (III), since $H = N(lP + mQ + n)$ and $K = N(P\delta l + Q\delta m + \delta n)$, it occurred to me that the sign of N might at least be determined by neglecting Γ and the errors in the assumed values of L, M, and N; and not only is this the case, but also *Vega*, *Altair*, and *Arcturus* agree so closely as to give almost the same value of Π, thus, by taking N with the negative sign, *Vega* gives $\Pi = +0''{\cdot}02$; *Altair*, $+0''{\cdot}03$, and *Arcturus*, $+0''{\cdot}02$ again. Of course no importance can be attached to this numerical agreement as far as the value of Π itself is concerned, but it is highly satisfactory to know that all reasons combine to direct us in making the decision.

It therefore appears that the centre lies in the direction of the point whose coordinates for the year 1850 are

R A	10°	26′
N P D	62	9,

so that L, M, and N are all negative, and

$$\log L = -9{\cdot}93930,$$
$$\log M = -9{\cdot}20444,$$
$$\log N = -9{\cdot}66946,$$

where of course the signs before the logarithms apply to the natural numbers —in these, and in all following cases. And instead of the general equation marked by (4), we have

$$v^2 = Fr_o^2 \qquad \text{(IV)}$$

But this equation only applies to circular orbits; consequently, if the solar orbit is assumed to be elliptical, it will require a slight modification, perhaps the most convenient form is

$$V^2 = FR_o^2 + AV^2$$

where AV^2 is the correction to V^2 on account of that ellipticity, and then A will become a constant for the whole system, such as Γ and Π, having a very small numerical value.

The principal equations (I), (II), (III), and (IV) must now be reduced and adapted for the computation of parallax Substituting from (I) and (II) in (IV), we have

$$V^2+\left(\frac{d\rho}{dt}\right)^2+2V\left(a\frac{d\rho}{dt}+b\rho_o\right)+c^2\rho_o^{\,2}=F\left(R_o^{\,2}+\rho_o^{\,2}+2\mathrm{II}R_o\rho_o\right),$$

but

$$V^2-FR_o^{\,2}=\Lambda V^2,$$

so that

$$\left(\frac{d\rho}{dt}\right)^2+2V\left(a\frac{d\rho}{dt}+b\rho_o\right)+c^2\rho_o^{\,2}=F\rho_o\left(\rho_o+2\mathrm{II}R_o\right)-\Lambda V^2,$$

but

$$F=\Pi^2V^2(1-\Lambda),$$

so the right-hand member of this equation becomes

$$V^2\{\Pi^2(1-\Lambda)\,\rho_o^{\,2}+2\mathrm{II}\Pi(1-\Lambda)\,\rho_o-\Lambda\}$$

Multiply both sides by ϖ^2, then

$$\left(\varpi\frac{d\rho}{dt}\right)^2+2\varpi V\left(a\varpi\frac{d\rho}{dt}+b\right)+c^2=V^2\{\Pi^2(1-\Lambda)+2\mathrm{II}\Pi(1-\Lambda)\,\varpi-\Lambda\varpi^2\}$$

It will still be convenient to employ the auxiliary equation

$$\frac{d\rho}{dt}+u\rho_o=0,$$

then, from (III), we easily obtain

$$u=\frac{K+a\Pi V+\varpi\Gamma V}{\mathrm{II}+\Pi\rho_o}, \tag{9}$$

and the above equation becomes

$$u^2-2\varpi V(au-b)+c^2=V^2\{\Pi^2(1-\Lambda)+2\mathrm{II}\Pi(1-\Lambda)\,\varpi-\Lambda\varpi^2\},$$

and then

$$\varpi=\frac{c^2+u^2-V^2\{\Pi^2(1-\Lambda)-\Lambda\varpi^2\}}{2V\{au-b+\mathrm{II}\Pi V(1-\Lambda)\}} \tag{10}$$

Equations (9) and (10) now take the place of (7) and (8), it will be noticed that an approximate value of ϖ is required before the parallax can be obtained from these formulæ, but such an approximation may be obtained from (7) and (8), or from any tentative method of solution

But as yet Γ, Λ, and Π are unknown; neither can they be obtained without considering at the same time the corrections which must be applied to L, M, N, and V; but it will be convenient to suppose that approximate values of Γ, Λ, and Π are also known, so that it will not afterwards be necessary to modify the following part of the work in order to introduce their corrections. We shall represent these corrections by the prefix Δ, so that ΔL is the correction to be added to L, but it will be noticed that there are only five corrections to be found, namely, ΔL, ΔM, ΔV, $\Delta\Lambda$, and $\Delta\Pi$; to find ΔN in terms of ΔL and ΔM, we have only to differentiate the equation $L^2 + M^2 + N^2 = 1$; or it may be found from $(L + \Delta L)^2 + (M + \Delta M)^2 + (N + \Delta N)^2 = 1$, should ΔL and ΔM be so large that their squares and products cannot be neglected. And since

$$\Gamma = L\lambda + M\mu + N\nu,$$

we have

$$\Delta\Gamma = \lambda\Delta L + \mu\Delta M + \nu\Delta N$$

In order to give a general idea of the method to be adopted in finding these corrections, let $\varpi + \Delta\varpi$ be the true parallax of a star, where, as usual, ϖ represents the theoretical parallax calculated by means of the foregoing formulæ and the uncorrected values of the constants; then, if $\Delta\varpi$ be expressed in terms of the corrections, we shall be able to determine the latter, but it is now necessary to show how this may be done

Referring to equation (10), let

$$\varepsilon = 2\varpi V\{au - b + \Pi\Pi V\,(1 - \Lambda)\} - c^2 - u^2 + V^2\{\Pi^2\,(1 - \Lambda) - \Lambda\varpi^2\},$$

so that, if all the quantities have been rightly taken,

$$\varepsilon = 0$$

Now ϵ may be regarded as a function of ϖ, L, M, V, Λ, and Π; and if any one of them be changed, there will be a corresponding change in ϵ, and if $\Delta\epsilon$ be the sum of all such changes produced by the changes $\Delta\varpi$, ΔL, ΔM, ΔV, $\Delta\Lambda$, and $\Delta\Pi$, then

$$\Delta\varepsilon = \Delta\varpi\frac{d\varepsilon}{d\varpi} + \Delta L\frac{d\varepsilon}{dL} + \Delta M\frac{d\varepsilon}{dM} + \Delta V\frac{d\varepsilon}{dV} + \Delta\Lambda\frac{d\varepsilon}{d\Lambda} + \Delta\Pi\frac{d\varepsilon}{d\Pi}.$$

Now let us put

$$\frac{d\varepsilon}{dL} = A\,\frac{d\varepsilon}{d\varpi},$$

$$\frac{d\varepsilon}{dM} = B\,\frac{d\varepsilon}{d\varpi},$$

$$\frac{d\varepsilon}{dV} = C\,\frac{d\varepsilon}{d\varpi},$$

$$\frac{d\varepsilon}{d\Lambda} = D\,\frac{d\varepsilon}{d\varpi},$$

$$\frac{d\varepsilon}{d\Pi} = E\,\frac{d\varepsilon}{d\varpi},$$

and putting $\Delta\epsilon = 0$, so that equation (10) may hold good, we have the equation

$$A\Delta L + B\Delta M + C\Delta V + D\Delta\Lambda + E\Delta\Pi + \Delta\varpi = 0,$$

which expresses $\Delta\varpi$ in terms of the corrections Each star will give us an equation similar to the above , and supposing that a large number are employed, or at least more than five, each equation must be multiplied by its proper weight, and then the system of equations must be solved by the method of Least Squares Now $\Delta\varpi$ is the observed minus the calculated parallax, so that the probable error of $\Delta\varpi$ is that of the observed parallax , and therefore the weights are inversely proportional to the squares of the probable errors of the observed parallaxes

It now remains to find the partial differential coefficients $\frac{d\varepsilon}{d\varpi}$, $\frac{d\varepsilon}{dL}$, $\frac{d\varepsilon}{dM}$, $\frac{d\varepsilon}{dV}$, $\frac{d\varepsilon}{d\Lambda}$, and $\frac{d\varepsilon}{d\Pi}$, differentiating the expression for ε with respect to ϖ, remembering that u is a function of ϖ, we have

$$\frac{d\varepsilon}{d\varpi} = 2V\{au - b + \Pi\Pi V(1-\Lambda)\} + 2(a\varpi V - u)\frac{du}{d\varpi} - 2\varpi\Lambda V^2$$

But from (9),

$$\frac{du}{d\varpi}(H + \Pi\rho_o) + u\Pi\,\frac{d\rho_o}{d\varpi} = \Gamma V,$$

and

$$\frac{\partial\rho_o}{d\varpi} = -\frac{1}{\varpi^2} = -\rho_o^2,$$

therefore

$$\frac{du}{d\varpi} = \frac{\Gamma V + u\rho_o^2\Pi}{H + \Pi\rho_o}$$

Now

$$a\varpi\mathrm{V} - u = \varpi\,(a\mathrm{V} - u\rho_o) = \varpi\left(a\mathrm{V} + \frac{d\rho}{dt}\right),$$

therefore, if

$$\mathrm{S} = \frac{\varpi\left(a\mathrm{V} + \frac{d\rho}{d}\right)}{\Pi + \Pi\rho_o},$$

we have finally

$$\frac{d\varepsilon}{d\varpi} = 2\mathrm{V}\,\{au - b + \mathrm{H}\Pi\mathrm{V}\ (1 - \Lambda)\} + 2\mathrm{S}\,(\Gamma\mathrm{V} + u\rho_o{}^2\,\Pi) - 2\varpi\Lambda\mathrm{V}^2$$

For the next differential coefficient, we have

$$\frac{d\varepsilon}{d\mathrm{L}} = 2\,(a\varpi\mathrm{V} - u)\,\frac{du}{d\mathrm{L}} + 2\varpi\Pi\mathrm{V}^2\,(1 - \Lambda)\,\frac{d\Pi}{d\mathrm{L}},$$

and from (9),

$$\frac{du}{d\mathrm{L}}\,(\Pi + \Pi\rho_o) = \frac{d\mathrm{K}}{d\mathrm{L}} + \varpi\mathrm{V}\,\frac{d\Gamma}{d\mathrm{L}} - u\,\frac{d\Pi}{d\mathrm{L}},$$

therefore

$$\frac{d\varepsilon}{d\mathrm{L}} = 2\mathrm{S}\,\frac{d\mathrm{K}}{d\mathrm{L}} + 2\,\{\varpi\Pi\mathrm{V}^2\,(1 - \Lambda) - u\mathrm{S}\}\,\frac{d\Pi}{d\mathrm{L}} + 2\varpi\mathrm{V}\mathrm{S}\,\frac{d\Gamma}{d\mathrm{L}}$$

But

$$\frac{d\Gamma}{d\mathrm{L}} = \lambda + \nu\,\frac{d\mathrm{N}}{d\mathrm{L}},$$

$$\frac{d\Pi}{d\mathrm{L}} = l + n\,\frac{d\mathrm{N}}{d\mathrm{L}},$$

$$\frac{d\mathrm{K}}{d\mathrm{L}} = \delta l + \delta n\,\frac{d\mathrm{N}}{d\mathrm{L}},$$

and

$$\mathrm{N}\,\frac{d\mathrm{N}}{d\mathrm{L}} = -\mathrm{L}, \quad \text{or} \quad \frac{d\mathrm{N}}{d\mathrm{L}} = -\mathrm{P},$$

therefore

$$\frac{d\Gamma}{d\mathrm{L}} = \lambda - \nu\mathrm{P},$$

$$\frac{d\Pi}{d\mathrm{L}} = l - n\mathrm{P},$$

$$\frac{d\mathrm{K}}{d\mathrm{L}} = \delta l - \mathrm{P}\delta n,$$

and if

$$U = \delta l - P\delta n - u\,(l - nP) + \varpi V\,(\lambda - \nu P),$$

we have

$$\frac{d\varepsilon}{dL} = 2SU + 2\varpi\Pi V^2\,(1-\Lambda)\,(l-nP)$$

Similarly if

$$W = \delta m - Q\delta n - u\,(m - nQ) + \varpi V\,(\mu - \nu Q),$$

$$\frac{d\varepsilon}{dM} = 2SW + 2\varpi\Pi V^2\,(1-\Lambda)\,(m-nQ)$$

And also

$$\frac{d\varepsilon}{dV} = 2\varpi\{au - b + H\Pi V\,(1-\Lambda)\} + 2S\,(a\Pi + \varpi\Gamma) + 2V\{\Pi^2\,(1-\Lambda) - \Lambda\varpi^2 + \varpi H\Pi\,(1-\Lambda)\},$$

$$\frac{d\varepsilon}{d\Lambda} = -V^2\,(\varpi^2 + 2\varpi H\Pi + \Pi^2),$$

$$\frac{d\varepsilon}{d\Pi} = 2S\left(aV + \frac{d\rho}{dt}\right) + 2\varpi V^2\,(1-\Lambda)\,(\Pi + \Pi\rho_0)$$

Finally, to obtain the coefficients A, B, C, D, and E, it is only necessary to divide $\frac{d\varepsilon}{dL}$, $\frac{d\varepsilon}{dM}$, $\frac{d\varepsilon}{dV}$, $\frac{d\varepsilon}{d\Lambda}$, and $\frac{d\varepsilon}{d\Pi}$ by $\frac{d\varepsilon}{d\varpi}$, and therefore those coefficients have been expressed in terms of known quantities and the unknown quantities Γ, Λ, and Π

Referring to page 173, it appears that there are at present only 10 stars which can be employed in forming equations similar to

$$A\Delta L + B\Delta M + C\Delta V + D\Delta\Lambda + E\Delta\Pi + \Delta\varpi = 0$$

whose solution will give the required corrections ΔL, ΔM, ΔV, $\Delta\Lambda$, and $\Delta\Pi$; they are

	$\Delta\varpi$		$\Delta\varpi$
α Centauri	$0''.00$	Capella	$+0''.03$
61 Cygni	0.00	Altair	$+0.04$
Arcturus	-0.07	70 *p* Ophiuchi	$+0.04$
Vega	$+0.03$	21258 Lalande	-0.05
Procyon	$+0.04$	34 Groombridge	$+0.12$

With regard to the weights which must be given to these equations, from those numbers whose arithmetical mean was taken as the parallax of *α Centauri*, it will be found that the probable error of the mean is $\pm 0''.014$, and similarly for 61 *Cygni*, the probable error is $\pm 0''.032$, and since $\pm 0''.064$ is the probable error of each of the four determinations in the case of the latter star, we shall assume this error for all the rest, hence the weight of the first equation is 21, that of the second 4, and of the rest unity.

Now, by putting Γ, Λ, and Π each equal to zero, we can obtain a first approximation to the coefficients A, B, C, D, and E, and then a first approximation to the corrections ΔL, ΔM, ΔV, ΔΛ, and ΔΠ; but unfortunately it will be found that these corrections are large—so large that ΔL, ΔM, and therefore ΔN and Γ, cannot be neglected in recomputing the coefficients in order to proceed to a second approximation If they are neglected, the second approximation will lead us astray by increasing those corrections It would therefore be necessary to recompute the whole of the numerical part of the work, if it were possible, and to employ the new values of L, M, N, V, Γ, Λ, and Π according to the first approximation, but it is not possible, because the equations (9) and (10) break down and increase the errors Δϖ.

I have spent much time and trouble in trying to overcome this difficulty by varying the method of solution, for instance, by eliminating ΔL and ΔM by means of *α Centauri* and 61 *Cygni*, there were then only three unknown quantities to find from eight equations by the method of Least Squares; or by assuming different values of Γ, Λ, and Π in the first instance, but the results all proved to be unsatisfactory.

It will be remembered that we had the same difficulty before, when attempting to find P, Q, and V from a number of stars, and that the difficulty was overcome by rejecting the generality of the method ; it may perhaps be as well to do so again, and to lay these equations aside for the present

Assuming that the solar orbit is circular, and by putting Γ and Λ each equal to zero, the equations (9) and (10) become

$$u = \frac{K + a\Pi V}{H + \Pi\rho_o}, \qquad (11)$$

$$\varpi = \frac{c^2 + u^2 - H^2V^2}{2V(au - b + H\Pi V)}, \qquad (12)$$

and it will be interesting to know how far these equations will suit the proper motions and parallax of *Sirius*. It will be remembered that the equations (7) and (8) gave a negative value to the parallax, but as H is positive, the term HΠV in the denominator can be made to correct that defect; and it would seem possible to determine Π from (11) and (12) by means of the approximate values of L, M, N, and V, already found, and the observed parallax of *Sirius*; the latter may be taken to be 0″·21, which is the mean of two separate determinations.*

Assuming Π to be 0″·012, from (11) and (12) the parallax of *Sirius* becomes +0″·175, that of *α Centauri*, 0″·829, and that of 61 *Cygni*, 0″·430. It will therefore be possible to obtain a system by means of these three stars which will exactly satisfy their observed parallaxes and proper motions, and which will probably give better results for the other stars than the system formerly adopted; and as the constants of the new system may easily be found, we propose to make this important change.

Let ΔL, ΔV, and ΔΠ be the corrections which must be added to the values of L, V, and Π employed above, so that Δϖ, the difference between the observed and the computed parallax, may vanish in the case of the three stars *α Centauri*, 61 *Cygni*, and *Sirius*, then, in exactly the same manner in which Δϖ was expressed in terms of the corrections by means of the equations (9) and (10), we can now express Δϖ in terms of ΔL, ΔV, and ΔΠ, by means of the equations (11) and (12), always remembering that the equation

$$L\lambda+M\mu+N\nu=0$$

must now be introduced. As before, let

$$\frac{d\varepsilon}{dL}=A\frac{d\varepsilon}{d\varpi},$$

$$\frac{d\varepsilon}{dV}=C\frac{d\varepsilon}{d\varpi},$$

$$\frac{d\varepsilon}{d\Pi}=E\frac{d\varepsilon}{d\varpi},$$

then

$$A\Delta L+C\Delta V+E\Delta\Pi+\Delta\varpi=0$$

The following are the expressions for the partial differential coefficients.—

$$\frac{d\varepsilon}{d\varpi}=2V\,(au-b+\Pi\Pi V)+2u\rho_o{}^2\,S\Pi,$$

$$\frac{d\varepsilon}{dL}=2SU+2\varpi\Pi V^2\,(l+pm+qn),$$

$$\frac{d\varepsilon}{dV}=2\varpi\,(au-b+\Pi\Pi V)+2aS\Pi+2V\Pi^2+2\varpi\Pi\Pi V,$$

$$\frac{d\varepsilon}{d\Pi}=2\left(aV+\frac{d\rho}{dt}\right)S+2\varpi V^2\,(\Pi+\Pi\rho_o),$$

---

* 0″·15 HENDERSON, corrected by PETERS, 0″·27 ABBE. Probable error of the mean, ±0″·040.

where

$$S = \frac{\varpi\left(aV + \frac{d\rho}{dt}\right)}{H + \Pi\rho_o},$$

$$p = \frac{\nu L - \lambda N}{\mu N - \nu M},$$

$$q = \frac{\lambda M - \mu L}{\mu N - \nu M},$$

and

$$U = \delta l + p\delta m + q\delta n - u\,(l + pm + qn)$$

The quantities to be corrected are

$$L = -0\ 8696,$$
$$M = -0\ 1601,$$
$$N = -0\ 4672,$$
$$V = +9\ 9475,$$
$$\Pi = +0\ 0120,$$

whence we get the following tables.—

No	Star	log a	b	c''	Π	K
1	α Centauri	−9 24551	−1 342	12 923	+0 7970	+1 758
2	61 Cygni	+9 85467	−2 315	26 010	−0 6834	−3 124
3	Sirius	−9 95832	−0 525	1 791	+0 1210	+0 114

No	log $(H + \Pi\rho_o)$	log u	log $(au - b + H\Pi V)$	ϖ	$\Delta\varpi$
1	+9 90929	+10 33051	+10 02531	0′ 829	+0″ 107
2	−9 81657	+10 66616	+10 74437	0 430	−0 008
3	+9 27784	+ 8 50031	+ 9 70757	0 175	+0 035

No	log $\left(aV + \frac{d\rho}{dt}\right)$	log S	log $(l + pm + qn)$	log U
1	−10 63679	−10 64605	+10 08828	−10 93636
2	−10 56384	+10 38074	+ 9 48742	−10 92552
3	−10 96464	−10 92984	− 9 92850	+10 41979

No	$\log \frac{1}{2}\frac{d\epsilon}{d\varpi}$	$\log \frac{1}{2}\frac{d\epsilon}{dL}$	$\log \frac{1}{2}\frac{d\epsilon}{dV}$	$\log \frac{1}{2}\frac{d\epsilon}{d\Pi}$
1	+11 01620	+11 59591	+ 9 98597	+11 93323
2	+11 74774	−11 30287	+10 37543	−11 56455
3	+10 69618	−11 35303	+ 9 26928	+11 91228

And then the equations to be solved are

$$+3\;799\,\Delta L+0\;093\,\Delta V+\;8\;261\,\Delta\Pi+0\;107=0,$$
$$-0\;359\,\Delta L+0\;042\,\Delta V-\;0\;656\,\Delta\Pi-0\;008=0,$$
$$-4\;538\,\Delta L+0\;037\,\Delta V+16\;447\,\Delta\Pi+0\;035=0,$$

whence

$$\Delta L=-0\;0144,$$
$$\Delta V=-0\;0266,$$
$$\Delta\Pi=-0\;0060$$

Now, if the squares and products of ΔL, ΔM, and ΔN can be neglected, we have $\Delta M=p\Delta L$, and $\Delta N=q\Delta L$, but since ΔL is tolerably large, it will be better to determine M and N directly from the equations

$$L\lambda+M\mu+N\nu=0,$$
$$L^2+M^2+N^2=1,$$

employing the corrected values of L, which is $-0\;8840$, eliminating N, the resulting equation for M is a quadratic, but of course we know which root to take, hence

$$M=-\frac{L\lambda\mu+[\{\nu^2-L^2(\lambda^2+\nu^2)\}(\mu^2+\nu^2)+L^2\lambda^2\mu^2]^{\frac{1}{2}}}{\mu^2+\nu^2},$$

so that $M=-0\;1428$, and then $N=-0\;4452$; collecting the new values of the constants, we find

$$L=-0\;8840,$$
$$M=-0\;1428,$$
$$N=-0\;4452,$$
$$V=+9\;9209,$$
$$\Pi=+0\;0060$$

But when these constants are employed in equations (11) and (12), it will be found that they do not exactly satisfy the adopted parallaxes of *α Centauri*, 61 *Cygni*, and *Sirius*, the outstanding errors are

	$\Delta\varpi$
α Centauri	$-0''.014$
61 Cygni	0.000
Sirius	-0.013

and they are due to the magnitude of the corrections, whose squares and products are quite sensible ; consequently it becomes necessary to repeat the process, or at least a part of it, when the following values of the constants will be found to exactly satisfy the required conditions —

$$L = -0.8831,$$
$$M = -0.1439,$$
$$N = -0.4466,$$
$$V = +9.9430,$$
$$\Pi = +0.00665$$

The new position of the centre when viewed from the Sun is, for the year 1850,

	°	′
R.A.	9	15
N.P.D.	63	28

This point is about 1° south, preceding the small double star of the sixth magnitude, 65 *Piscium* (*i*), there are three small nebulæ in its immediate neighbourhood, of which the nearest and brightest is No. 136 in Sir John Herschel's General Catalogue (*Philosophical Transactions*, vol. cliv.), so that there is nothing visible near the centre to attract, and perhaps divert, our attention.

Before calculating the parallaxes of other stars according to the new system, it will be advisable to collect all the necessary expressions and formulæ, and to tabulate those functions which may be useful afterwards.

Column M in Table I. contains the magnitudes of the stars, decimally subdivided, and taken from Sir John Herschel's *Outlines of Astronomy* when possible ; the Right Ascensions in the same Table are given in time to the nearest second, but in the calculations they were previously expressed in arc to the nearest minute, the columns "P M. in R A" and "P M. in N P D," which give the proper motions in Right Ascension and North Polar Distance respectively, have been taken, when possible, from Mr. MAIN'S Paper in vol xix. of the *Memoirs of the Royal Astronomical Society*

FORMULÆ

θ = North Polar Distance, ϕ = Right Ascension } of a star, Jan 1 0, 1850

$\delta\theta$ = Annual proper motion in θ, $\delta\phi$ = Annual proper motion in ϕ } in seconds of arc

ϖ = Annual parallax, in seconds of arc

ρ_o = Distance in sidereal units $= \frac{1}{\varpi}$

$\frac{d\rho}{dt}$ = Annual change in distance, taking the radius of the Earth's orbit as the unit of space

$$l = \sin\theta\cos\phi, \qquad \delta l = n\cos\phi\,\delta\theta - m\delta\phi,$$

$$m = \sin\theta\sin\phi, \qquad \delta m = n\sin\phi\,\delta\theta + l\delta\phi,$$

$$n = \cos\theta, \qquad \delta n = -\sin\theta\,\delta\theta$$

$$a = l\lambda + m\mu + n\nu, \qquad \log\lambda = -\ 9\ 16642,$$

$$b = \lambda\delta l + \mu\delta m + \nu\delta n, \qquad \log\mu = -\ 9\ 91350,$$

$$c^2 = \delta l^2 + \delta m^2 + \delta n^2, \qquad \log\nu = +\ 9\ 74360,$$

$$\mathrm{H} = l\mathrm{L} + m\mathrm{M} + n\mathrm{N}, \qquad \log \mathrm{L} = -\ 9\ 94601,$$

$$\mathrm{K} = \mathrm{L}\delta l + \mathrm{M}\delta m + \mathrm{N}\delta n, \qquad \log \mathrm{M} = -\ 9\ 15806,$$

$$u = \frac{\mathrm{K} + a\Pi\mathrm{V}}{\mathrm{H} + \Pi\rho_o}, \qquad \log \mathrm{N} = -\ 9\ 64992,$$

$$\log \Pi = +\ 7\ 82282,$$

$$\varpi = \frac{c^2 + u^2 - \Pi^2\mathrm{V}^2}{2\mathrm{V}\,(au - b + \mathrm{H}\Pi\mathrm{V})}, \qquad \log \Pi\mathrm{V} = +\ 8\ 82034,$$

$$\log 2\mathrm{V} = +11\ 29855,$$

$$\frac{\delta\rho}{dt} = -\frac{u}{\varpi} \qquad \Pi^2\mathrm{V}^2 = 0\ 0044$$

TABLE I

No	Star	M	R A			P M in R A	N P D		P M in N P D
			hrs	min	sec	sec	°	′	″
1	*α* Centauri	0 6	14	29	27	−0 471	150	13	−0 78
2	61 Cygni	5 5	21	0	11	+ 342	51	59	−3 11
3	*α* Canis Majoris (*Sirius*)	0 1	6	38	32	− 035	106	31	+1 24
4	*α* Bootis (*Arcturus*)	0 8	14	8	49	− 079	70	2	+1 93
5	*α* Lyræ (*Vega*)	1 0	18	31	51	+ 017	51	21	−0 28
6	*α* Canis Minoris (*Procyon*)	1 0	7	31	27	− 048	84	24	+1 08
7	*α* Aurigæ (*Capella*)	1 0	5	5	37	+ 008	44	10	+0 43
8	*α* Aquilæ (*Altair*)	1 3	19	43	28	+ 036	81	32	−0·38
9	70 *p* Ophiuchi	4 5	17	57	53	+ 017	87	28	+1 09
10	21258 Lalande	8 5	10	57	39	− 386	45	41	+1 36
11	34 Groombridge		0	9	52	+ 255	46	50	−0 37
12	*α* Ursæ Minoris (*Polaris*)	2 3	1	5	1	+ 065	1	29	0 00
13	*ι* Ursæ Majoris	3 5	8	48	55	− 047	41	22	+0 28
14	1830 Groombridge	6 5	11	44	19	+ 314	51	12	+5 70
15	*σ* Draconis	5 0	19	32	38	+ 096	20	36	+1 79
16	17415 Oeltzen	9 0	17	37	17	− 07	21	33	+1 20

TABLE II

No	log l	log m	log n	log δl	log δm	log δn
1	−9 59635	−9 47924	−9 93847	−10 42619	+10 37621	+ 9 58820
2	+9 74629	−9 74554	+9 78950	+10 17609	+10 62469	+10 38919
3	−9 20531	+9 97553	−9 45377	+ 9 74429	− 9 41996	−10 07518
4	−9 90055	−9 69971	+9 53336	−10 06108	+ 9 77159	−10 25864
5	+9 03439	−9 88843	+9 79558	+ 9 23805	+ 9 30320	+ 9 33980
6	−9 58741	+9 96237	+8 98937	+ 9 79169	+ 9 57519	−10 03134
7	+9 21441	+9 83073	+9 85571	− 7 95424	+ 9 50515	− 9 47655
8	+9 63500	−9 94939	+9 16801	+ 9 65896	+ 9 45179	+ 9 57502
9	−7 96845	−9 99956	+8 64543	+ 9 40483	− 8 70757	−10 03701
10	−9 83833	+9 28377	+9 84424	+ 9 29667	+10 62798	− 9 98811
11	+9 86255	+8 49680	+9 83513	− 9 57171	+10 44348	+ 9 43115
12	+8 39536	+7 85996	+9 99985	− 7 84896	+ 8 38436	− ∞
13	−9 64759	+9 68959	+9 87535	+ 9 30963	+ 9 67117	− 9 26717
14	−9 89071	+8 72619	+9 79699	−10 58410	−10 57611	−10 64760
15	+9 14119	−9 50984	+9 97130	+10 05115	−10 12743	− 9 79920
16	−8 56081	−9 56290	+9 96853	− 9 69373	−10 03019	− 9 64422

TABLE III

No	log a	b	c^2	H	K	log $(H + \Pi\rho_0)$	log $(K + a\Pi V)$
1	−9 24551	−1 342	12 923	+0 7796	+1 841	+9 89581	+10 26221
2	+9 85467	−2 315	26 010	− 6874	−3 025	−9 82711	−10 47392
3	−9 95832	−0 525	1 791	+ 1327	+0 079	+9 21590	+ 8 27184
4	+9 85509	−1 321	4 965	+ 6219	+1 742	+9 81776	+10 25261
5	+9 98408	−0 069	0 118	− 2632	−0 279	−9 22220	− 9 33244
6	−9 80659	−0 995	1 680	+ 1660	−0 121	+9 40807	− 9 21219
7	−9 25888	−0 427	0 192	− 5625	+0 096	−9 52270	+ 8 92428
8	+9 87367	−0 091	0 429	− 3188	−0 611	−9 43648	− 9 74974
9	+9 92655	−0 599	1 253	+ 1322	+0 269	+9 29973	+ 9 51188
10	+9 51943	−4 048	19 014	+ 2689	−0 351	+9 46687	− 9 51720
11	+9 39175	−2 071	7 920	− 9536	−0 191	−9 96355	− 9 24304
12	+9 73584	−0 019	0 001	− 4694	+0 003	+9 61458	+ 8 59106
13	+8 90363	−0 517	0 296	− 0133	−0 165	−8 08279	− 9 20412
14	+9 62086	+1 189	48 659	+ 3991	+5 915	+9 60379	+10 77401
15	+9 88275	+0 585	3 461	− 4937	−0 519	−9 69046	− 9 67117
16	+9 91392	+0 707	1 588	− 3307	+0 788		

TABLE IV

No	log u	HΠV	$\log\left\{\begin{matrix} au-b \\ +H\Pi V\end{matrix}\right\}$	log ϖ	ϖ	ρ_0	$\frac{d\rho}{dt}$
1	+10 36640	+0 052	+ 9 99317	9 97130	0″ 936	1 07	− 2 48
2	+10 64681	− 046	+10 73576	9 62530	0 422	2 37	−10 51
3	+ 9 05594	+ 009	+ 9 63448	9 32224	0 210	4 76	− 0 54
4	+10 43485	+ 041	+10 52009	9 27369	0 188	5 33	−14 49
5	+10 11024	− 017	+10 11227	8 83838	0 069	14 51	−18 70
6	− 9 80412	+ 011	+10 15045	8 86948	0 074	13 51	+ 8 60
7	− 9 40158	− 037	+ 9 63949	8 46336	0 029	34 41	+ 8 67
8	+10 31326	− 021	+10 20629	9 16327	0 146	6 87	−14 13
9	+10 21215	+ 009	+10 29754	8 99553	0 099	10 10	−16 47
10	−10 05033	+ 018	+10 56761	9 44071	0 276	3 63	+ 4 07
11	+ 9 27949	− ·063	+10 31281	9 28912	0 195	5 14	− 0 98
12	+ 8 97648	− 031	+ 8 60206	7 87754	0 008	132 57	−12 56
13	+11 12133	− 001	+10 19728	10 74756			
14	+11 17022	+ 026	+10 70053	10 42851			
15	+ 9 98071	− 033	+ 9 04922	10 29291			
16							

From the last Table it appears that the system has been greatly improved, excepting the two stars *Procyon* and 70 *p Ophiuchi*, the calculated parallaxes of all the rest have approached their observed values, and the sum of the squares of the errors of $\Delta\varpi$ (given in page 180) have been reduced from 0 0284 to 0 0246; and, moreover, both *Sirius* and *Polaris* are now included in the system

A few remarks are necessary about some stars not fully discussed before, these are as follows

SIRIUS

It will be observed that the computed radial velocity of this star will be quite insensible in the spectroscope, but Dr HUGGINS found it to be +6·9, so that a difficulty presents itself Now Dr VOGEL's observations made the velocity only half that amount, or about +3 5, so perhaps this is the extent of the error due to the imperfect state of the theory, and as we know that very small changes in the constants will greatly affect *Sirius*, the difference between observation and theory may really be very small. Moreover, the irregularities of the proper motions of *Sirius* have been proved to be due to a binary system combining the bright with a dark star; no allowance has been made for the effect of this orbital velocity, and I am not in possession of the data necessary for its calculation

ι URSÆ MAJORIS

This star is very nearly 90° from both the solar apex and the centre; in this position the slightest change in the constants will have very great effect upon the parallax, and assuming that the parallax of 0″ 133 found by Dr PETERS is correct, we should rather reverse the process and determine some of the constants by means of this star The parallax really found is very large, but it has been omitted in Table IV because it is not trustworthy

1830 GROOMBRIDGE

It is to be noticed that, for this and the remaining two stars, the function *b* is positive, while *b* is negative for all the rest, by referring to the expressions for a and b, this circumstance expresses the fact that these three stars move towards the solar apex, while all the rest we have considered move from it.

The observations for the parallax of 1830 Groombridge have given contradictory results; Dr WICHMAN found a parallax of 0″ 72, while that of a comparison star was 1″ 17; Dr PETERS made it 0″ 226, and M FAYE, 1″ 08, our system crowns these with a parallax of 2″ 68, but these numbers must not be regarded as trustworthy I am at a loss to account for the failure in this case, the proper motions employed are those of Dr ARGELANDER given in the British Association Catalogue, and they have lately been confirmed by observations at Greenwich, according to Mr LYNN.

σ DRACONIS

The parallax is 0″·255 according to Dr BRUNNOW, but the proper motions found by Mr MAIN make the theoretical parallax 1″ 96, which must be rejected, again there is no apparent cause for failure

17415 OELTZEN

The proper motions employed were given by Mr LYNN; perhaps I have made a false entry, at least these motions do not suit the system at all, because they give a negative parallax Thus, from equation (12) we can easily obtain the following quadratic for u

$$(u-a\varpi V)^2=(a\varpi V)^2-(c^2-\Pi^2V^2)-2\varpi V\,(b-\Pi\Pi V),$$

and it will be found that u will be impossible unless ϖ be greater than about 0″·3; but, from equation (11), u will be negative unless ϖ be very much smaller, so that u must be negative, and ϖ also, because a and b are both positive, hence there is complete failure for the third time A parallax of 0″ 247 has been assigned to it by M KRUGER, but as I have seen the same parallax applied to the star 7515 Oeltzen, perhaps there has been some error of a more obvious nature than in the other two cases

Table V contains these results for parallax, the numbers in the column "Observed Parallax" are those adopted as already mentioned in the case of each star; the numbers in the column "Computed Parallax" are taken directly from Table IV ; the differences, Δϖ, are given in the last; the sum of the first twelve differences is +0″·277, so that the mean difference is only +0″·223

TABLE V

No	Star	Observed Parallax	Computed Parallax	Δϖ = O−C
1	α Centauri	0″·936	0″·936	0″·000
2	61 Cygni	·422	·422	·000
3	Sirius	·210	·210	·000
4	Arcturus	·127	·188	− ·061
5	Vega	·090	·069	+ ·021
6	Procyon	·123	·074	+ ·049
7	Capella	·046	·029	+ ·017
8	Altair	·181	·146	+ ·035
9	70 *p* Ophiuchi	·160	·099	+ ·061
10	21258 Lalande	·260	·276	− ·016
11	34 Groombridge	·307	·195	+ ·112
12	Polaris	·067	·008	+ ·059
13	ι Ursæ Majoris	·133	?	?
14	1830 Groombridge	?	large	
15	σ Draconis	·255	large	
16	17415 Oeltzen	·247	negative	

Before a general discussion of radial velocities, it will be as well to refer to those already computed, on account of their great importance when considered conjointly with parallax

Star	Observed Rad Vel	Computed Rad Vel
Arcturus	−19·0	−14·5
Vega	−17·5	−18·7
Altair	−13·3	−14·1
Procyon	+12 ?	+ 8·6
Capella	+ ?	+ 8·7
Sirius	+ 5·2 ?	− 0·5 ?

The reasons for adopting the numbers in the column of "Observed Radial Velocities" have been stated in the case of each star; the results for the first five stars may be considered as highly satisfactory; as for *Sirius*, it has been already stated that considerable uncertainty attends both the observed and the computed radial velocities · omitting this star, the mean error may be said to vanish

But Dr. Huggins has observed twenty-five other stars with the spectroscope, and these remain for discussion A new difficulty now presents itself; the proper motions of many of them are so very small that no reliance can be placed on the actual figures , that is to say, when a proper motion is stated to be 0″ 00, or ±0″ 01, it is quite clear that three places of decimals are required for numerical accuracy—a degree of precision which is at present altogether unauthorised Again, some of these stars with very small proper motions are theoretically at such immense distances that we could hardly hope for success , indeed, it will be remembered that, at the very beginning of the article, we proposed to confine our attention to the nearer stars which would be liable to the same systematic errors, so that these errors should be eliminated to a great extent, considering the stars *inter se* , consequently it will be necessary to reject the following stars as tests of the theory.

Star	P M in R A sec	P M in N P D ″
α Orionis	+0 001	0 00
β Orionis	−0 001	+0 02
α Cygni	+0 002	+0 01
γ Cygni	0 000	−0 02
α Pegasi	+0 003	+0 02
γ Pegasi	0 000	+0 02

Again, there are eight stars which are unfavourably situated , they are, α and β *Geminorum*, α, β, γ, δ, ε, and ζ *Ursæ Majoris* ; in the case of each of these stars H is small, and the parallax and radial velocity liable to considerable uncertainty

Out of the twenty-five stars there remain only eleven which we would select ; they are·

α, β, γ, δ Leonis,
η Ursæ Majoris,
α Virginis,
α Coronæ Borealis,

α Tauri,
γ Cassiopeiæ,
ε Bootis,
α Andromedæ,

and the computations are given in the following Tables·—

TABLE VI

No	Star	M	R A			P M in R A	N P D		P M in N P D
			hrs	min	sec	sec	°	′	″
17	α Leonis (*Regulus*)	1 6	10	0	23	−0 019	77	18	−0 01
18	β Leonis	2 6	11	41	24	− 036	74	35	+0 10
19	γ Leonis	2 3	10	11	42	+ 019	69	24	+0 15
20	δ Leonis	2 9	11	6	7	+ 011	68	39	+0 14
21	η Ursæ Majoris	2 2	13	41	37	− 012	39	56	+0 03
22	α Virginis (*Spica*)	1 4	13	17	18	− 005	100	23	+0 04
23	α Coronæ Borealis	2 7	15	28	20	+ 009	62	47	+0 07
24	α Tauri (*Aldebaran*)	1 1	4	27	19	+ 004	73	48	+0 17
25	γ Cassiopeiæ	2 5	0	47	42	− 008	30	6	−0 02
26	ε Bootis	2 8	14	38	26	− 005	62	17	−0 01
27	α Andromedæ	2 5	0	0	39	+ 009	61	44	+0 15

TABLE VII

No	log l	log m	log n.	log δl	log δm	log δn.
17	−9 92721	+9 68689	+9 34212	+9 14922	+9 38021	+7 98924
18	−9 98266	+8 89294	+9 42461	+8 20412	+9 71684	−8 98409
19	−9 92092	+9 62934	+9 54635	−9 22531	−9 33041	−9 14739
20	−9 95701	+9 33625	+9 56118	−8 92942	−9 13988	−9 11525
21	−9 76331	−9 43985	+9 88468	−8 84510	+8 97772	−8 28458
22	−9 96762	−9 51274	−9 25583	−8 25527	+8 85733	−8 59489
23	−9 73757	−9 84606	+9 66025	+8 87506	−8 99564	−8 79414
24	+9 57724	+9 94589	+9 44559	−8 53148	+8 81954	−9 21285
25	+9 69079	+9 01577	+9 93709	−7 69897	−8 79934	+8 00131
26	−9 83375	−9 75165	+9 66755	−8 59106	+8 73239	+7 94707
27	+9 94485	+7 40858	+9 67539	+8 85126	+9 07555	−9 12094

TABLE VIII

No	log a	b	c^2	H	K.	log (H + $\Pi\rho_0$)	log (K + $a\Pi$V)
17	−9 18355	−0 212	0 078	+0 5787	−0 163	+ 9 95961	−9 23805
18	+9 35064	−0 483	0 281	+ 7186	−0 046	+ 9 98448	−8 49136
19	−8 50243	+0 073	0 094	+ 5177	+0 242		
20	+9 19562	+0 053	0 043	+ 6061	+0 153	+ 9 80645	+9 21219
21	+9 86664	−0 078	0 014	+ 2092	+0 057	+10 18730	+9 02531
22	+9 48159	−0 078	0 007	+ 9470	+0 023	+10 86038	+8 63347
23	+9 95832	+0 036	0 019	+ 3793	−0 024	+ 9 82066	+8 55630
24	−9 79532	−0 140	0 032	− 5853	+0 093	− 9 31952	+8 71600
25	+9 50840	+0 058	0 004	− 8346	+0 009		
26	+9 91397	−0 034	0 005	+ 4758	+0 023	+10 99410	+8 88649
27	+9 11760	−0 181	0 037	− 9897	−0 021	− 9 72165	−8 07918

TABLE IX

No	log u	HΠV	$\log\left\{\begin{matrix} au-b \\ +\text{H}\Pi\text{V}\end{matrix}\right\}$	log ϖ	ϖ	ρ_0	$\frac{d\rho}{dt}$
17	−9 27844	+0 038	+9 44560	8 29724	0″020	50 44	+ 9 58
18	−8 50688	+ 048	+9 71933	8 42616	0 027	37 48	+ 1 20
19							
20	+9 40574	+ 040	+8 43136	9 28712	0 194	5 16	− 1 31
21	+8 83801	+ 014	+9 15534	7 72220	0 005	189 60	−13 06
22	+7 77309	+ 063	+9 15534	7 02323	0 001	947 90	− 5 62
23	+8 73564	+ 025	+8 57978	8 37694	0 024	41 98	− 2 28
24	−9 39648	− 039	+9 40993	8 24576	0 018	56 79	+14 15
25							
26	+7 89239	+ 031	+8 85126	6 85019	0 001	1412 00	−11 02
27	+8 35753	− 065	+9 07555	8 15738	0 014	69 60	− 1 59

Now, by referring to the Paper read by Dr. HUGGINS before the Royal Society in the year 1872, it will be found that he considered none of the observations made upon any one of these stars as satisfactory, some were only once observed under unfavourable circumstances, and all required confirmation.

Again, it appears that the subject has been taken up at Greenwich, and some of the results are published in the *Monthly Notices* for November 1875, and it very fortunately happened that the pamphlet was sent to me for a different purpose. From the manner in which these observations are recorded, the great difficulty and uncertainty is made so apparent, that perhaps these computed radial velocities are as fairly in accordance with observation as the present state of circumstances will allow us to expect

Thus, out of the eleven stars, five are in accordance with the observations of Dr HUGGINS, as far as the direction of the motion is concerned, namely:

	Computed Rad Vel
Regulus	+ 9 6
β Leonis	+ 1 2
Aldebaran	+14 2
ε Bootis	−11 2
α Andromedæ	− 1 6,

and there are two similarly in accordance with the observations at Greenwich:

	Computed Rad Vel
η Ursæ Majoris	−13 1
α Coronæ Borealis	− 2 3

But there are two which may be wrong:

	Computed Rad Vel
δ Leonis	− 1 3
Spica	− 5 6,

and there still remain two stars, *γ Leonis* and *γ Cassiopeiæ*, for which no results can be obtained.

It therefore happens that these general observations do not greatly assist us, and without the stars *Arcturus*, *Vega*, *Altair*, and *Procyon*, the theory would not have been tested in a satisfactory manner.

A few words in conclusion respecting the whole system:—The component members will all revolve about the centre in the same time, which may easily be found from the Sun's motion. Thus $\frac{V}{R}$ is the angular motion of the Sun round the centre in one year, expressed in circular measure, and $\frac{V}{R \sin 1''}$ is the same velocity expressed in seconds of arc; but $R \sin 1'' = R_0 = \frac{1}{\Pi}$, therefore $\frac{V}{R \sin 1''} = \Pi V$, a quantity which has continually occurred, and whose logarithm is given among the formulæ The angular velocity of the Sun about the centre is therefore 0″.06612 per annum, and the Sun will require about 20 millions of years to perform a revolution This is the Annus Magnus which restores all the stars to their same relative positions.

It was conjectured by Sir JOHN HERSCHEL, and perhaps rightly, that the centre of any grand motion must lie in the plane of the Galaxy; but it must be remembered that the Sun is probably situated somewhat to the north of that plane, and therefore, when we look towards the centre, the line of sight must pass through the Galactic Plane, and it may possibly happen that the centre is situated in that stratum of stars, although its comparative proximity projects it far below the Milky Way.

With regard to the whole mass of matter contained within the sphere whose radius is R, and which therefore acts upon the Sun, the well-known equation

$$T^2 = \frac{4\pi^2 R^3}{\Sigma m}$$

will give Σm, the whole mass of matter, in terms of T and R, the periodic time and mean distance respectively. Taking the mass of the Sun as unity,

$$\Sigma m = \frac{R^3}{T^2} = \frac{(31{,}020{,}000)^3}{(19{,}600{,}000)^2} = 77{,}680{,}000\,,$$

or the whole attractive mass is about 78 million times that of the Sun

Now, from the gauges of the two HERSCHELS, it appears that the stars are distributed in strata parallel to the Galactic Plane, and that the star-density of these strata diminishes on either side of the plane according to some function of the distance. Hence we cannot form an estimate of the number of the stars whose collective mass has just been found, without a discussion of those gauges, but, assuming that the stars are uniformly distributed at threefourths of a sidereal unit apart, their number in the sphere whose radius is R would be about $\frac{4\pi}{3}\left(\frac{4R_o}{3}\right)^3$, or 34 millions , hence, on an average, the stars must be nearer together, or the average mass of each star must be larger than that of the Sun , but most probably the effect of clusters has thus become apparent.

It will be remembered that no allowance has been made for the variation of star-density in the present article, and this was one of the chief reasons why the problem was restricted to the nearer stars ; however, I have no wish to enter into these discussions at present, although a few words seemed necessary to show that there are no *à priori* objections to the theory ; but, on the other hand, I would point out the importance of confirming the stellar parallaxes already found, of obtaining a few more, and of observing all these stars with the spectroscope. The question of parallax makes the problem a restrictive one with regard to the number of stars to be employed ; but, with fifteen or twenty fundamental stars to work upon, the constants of the system may be accurately determined by those equations of condition which gave so much trouble before ; and, as I have every reason to believe that no great improvement to the system can be made until this may be effected, the publication of the theory in its present imperfect state becomes absolutely necessary for its further progress

Jamaica, September 1876

VI. *Mémoire sur la Période commune à la Fréquence des Taches Solaires et à la Variation de la Déclinaison Magnétique.* Par M. le Docteur Rudolf Wolf.

Il y a près d'un siècle que Christian Horrebow présuma une période dans la fréquence des taches solaires,* et un demi-siècle depuis que Heinrich Schwabe commença le dénombrement régulier de ces taches, lui permettant de se prononcer bientôt en faveur d'une telle périodicité ; mais Horrebow négligea de publier ses idées, et Schwabe ne réussit d'abord qu'à convaincre quelques-uns de ses contemporains de la réalité et de l'importance des résultats obtenus. L'année 1852 restera mémorable à jamais pour avoir changé tout d'un coup cette situation défavorable : c'est alors que Sabine découvrit que les deux courbes, dont l'une représente la fréquence des taches et l'autre la fréquence des perturbations magnétiques, s'accordent singulièrement, et que Gautier et *moi*, sans avoir connaissance de cette découverte, non encore publiée, nous trouvâmes, indépendamment l'un de l'autre, le même parallélisme entre la courbe de Schwabe et la courbe des variations de la déclinaison magnétique donnée par Lamont.

Il va sans dire que ces correspondances inattendues frappèrent tout le monde, et il me sembla donc de la plus haute importance d'étudier à fond leur réalité, révoquée en doute par quelques-uns de ces savants qui n'aiment pas accepter un fait étonnant dont la découverte leur a échappé. Je n'hésitai pas à rassembler et à discuter tous les documents relatifs à cette question, et je parvins à publier, vers la fin de l'année 1852, les premiers résultats de mes recherches, et à prouver, par l'ensemble des observations recueillies, *que la fréquence des taches solaires persiste à changer périodiquement depuis leur découverte en* 1610, *que la longueur moyenne de la période est de* $11\frac{1}{9}$ *ans, et que cette même période satisfait aux changements de la variation magnétique et même de la fréquence des aurores boréales* Depuis lors je continuai à rassembler les documents publiés et inédits sur l'histoire du soleil et des phénomènes correspondants, et j'en ai donné dans ma publication intitulée *Astronomische Mittheilungen* une série de 300 à 400 numéros, dont la liste suivante fournit un aperçu Depuis la découverte des taches solaires en 1610 par Johannes Fabricius on les a observées —

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* Voir la page 654 de mon ouvrage, *Geschichte der Astronomie*. Munchen, 1877.

Années	Observateurs	Littérature
1610–1613	Thomas Harriot	*MSS à Petworth* (Mitth 6, extrait)
1611–1667	Scheiner, Galilei, Marius, Gassendi, Riccioli, Kircher, etc	Scheiner, Rosa Ursina, Galilei, Macchie Solari, Marius, Mundus Jovialis, et Beschreibung des Cometen 1619, Gassendi, Opera, etc
1642–1661	Johannes Hevel . .	Hevel, Selenographia, Cometographia, et Epistolæ
1655–1690	Bosius, Petitus, Vogelius, Weickmann, Siverus, etc	Duhamel, Astronomia, Frick, Bedenken von den Cometen, Vagetius, De Maculis, etc.
1671–1748	Picard, Cassini, Lahire, Maraldi, Delisle, etc	Histoire de l'Académie des Sciences, Journal des Savans, Recueil d'Observations, etc
1680–1748	Gottfried et Christfried Kirch	*MSS à Berlin* (Mitth 23, extrait), Kirch, Himmelszeitung, etc
1680–1713	Eimmart, Ihle, Wurzelbauer, Wiedeburg, etc	Scheibel, Bucherkenntniss, Wurzelbauer, Uranies Noricæ, Wiedeburg, De Maculis, etc
1702–1736	Manfredi, Blanchini, Derham, Feuillée, etc	Manfredi, Descrizione d' alcune Macchie, Blanchini, Observationes Astronomicæ, Philos Transact, etc
1705–1726	François de Plantade .	*MSS à Montpellier* (Mitth 11, extrait)
1716–1738	Rost, Muller, Alischez, Adelbulner, Weidler, etc	Sammlung Breslauischer Medicis, Muller, Observationes, Adelbulner, Commercium, etc
1739–1751	F de Hagen .	*MSS à Poulkova* (Mitth 9, extrait)
1749–1799	Joh Casp Staudacher	*MSS à Nuremberg* (Mitth 4, extrait)
1750–1799	Darquier, Lalande, Messier, etc	Darquier, Observationes, Histoire de l'Académie des Sciences, Connaissance des Temps; etc.
1754–1760	Schubert et Zucconi .	Kayser, Resultate aus Beobachtungen von Sonnenflecken, Zucconi, De Heliometri Structura

Années	Observateurs	Littérature
1761–1806	Muller, Poczobut, Bugge, Dunn, Fixlmillner, etc	Smith, Cours d'Optique, Bugge, Observationes, Fixlmillner, Decennium Astronomicum, etc
1767–1776	Christian Horrebow	*MSS à Copenhague* (Mitth 19 et 33, extrait)
1769–1803	Wilson, Schulen, Herschel, Schroter, etc	Philos Transact, Schulen, Beiträge zur Dioptrik, Bode's Jahrbuch, etc
1773–1786	Jacques-André Mallet	*MSS à Genève* (Mitth 7, extrait)
1774–1822	Joh Elert Bode	*MSS à Berlin* (Mitth 23, extrait), Bode's Jahrbuch
1775–1802	Wolf, Boscovich, Hahn, Strnadt, Von Ende, etc	Bode's Jahrbuch, Boscovich, Opera, Ende, Geographische Ortsbestimmungen, etc
1781–1818	Placidus Heinrich .	*MSS à Munich* (Mitth 8, extrait), Bode's Jahrbuch, Zach, Monatl Corresp, etc
1788–1830	Honoré Flaugergues	*MSS à Montbart* (Mitth 13, extrait), Bode's Jahrbuch, Connaissance des Temps, etc
1797–1821	Gemeiner, Fritsch, Gruithuisen, Biela, etc	Bode's Jahrbuch, Zach, Monatl Corresp, Astron Nachrichten, etc
1813–1837	Augustin Stark	Meteorologische Jahrbucher
1816–1836	C Tevel . .	*MSS à Middelbourg* (Mitth 9, extrait)
1819–1823	C H Adams	*MSS. à Londres* (Mitth 14, extrait)
1819–1833	J W Pastorff	*MSS à Londres* (Mitth 36, extrait)
1821–1835	Argelander, Arago, Pons, Bohm, etc	Arago, Œuvres, Bohm, Beobachtungen von Sonnenflecken; Mitth 6, etc.
1825–1826	Von Both	*MSS à Breslau* (Mitth 33, extrait)
1826–1868	Heinrich Schwabe	*MSS autrefois à Dessau, à présent à Londres* (Mitth 10, extrait pour 1826–48, les observations des années suivantes sont jointes aux miennes dans Mitth. 1, etc)
1841–1875	Julius Schmidt	Schmidt, Resultate aus 11-jahrigen Beobachtungen, Astron Nachrichten; Mitth 25, etc.
1845–1860	Henry, Sestini, Main, Kreil, etc	Washington Astron Observations, Mitth 15, 21, etc
1847–1875	Rudolf Wolf . .	Berner Mittheilungen, Astronomische Mittheilungen.
1853–1861	Richard Carrington	Carrington, Observations of the Spots on the Sun, Warren de la Rue, Researches on Solar Physics, etc
1859–1875	Heinrich Weber .	Wochenschrift fur Astronomie, Mitth 16, etc
1860–1875	Waldner, Leppig, Tacchini, Schott, Sporer, De la Rue, Secchi, Jenzer, Franzenau, etc	Astron Nachrichten, Report of the Coast Survey, Memorie della Società degli Spettroscopisti Italiani; Bulletino Meteorol Romano, Mitth. 16, etc

Cette longue série d'observations me procurait les moyens nécessaires pour déterminer avec assez de sûreté chaque époque de maximum et de minimum survenue depuis la découverte des taches solaires, et d'en conclure la longueur de chaque période Je donne ci-jointe la table de ces époques et périodes, partagée en deux séries

Première Série				Seconde Série			
Minima		Maxima		Minima		Maxima	
1610 8		1615 5		1745 0		1750 3	
	8 2		10 5		10 2		11 2
1619 0		1626 0		1755 2		1761 5	
	15 0		13 5		11 3		8 2
1634 0		1639 5		1766 5		1769 7	
	11 0		9 5		9 0		8 7
1645 0		1649 0		1775 5		1778 4	
	10 0		11 0		9 2		9 7
1655 0		1660 0		1784 7		1788 1	
	11 0		15 0		13 6		16 1
1666 0		1675 0		1798 3		1804 2	
	13 5		10 0		12 3		12 2
1679 5		1685 0		1810 6		1816 4	
	10 0		8 0		12 7		13 5
1689 5		1693 0		1823 3		1829 9	
	8 5		12 5		10 6		7 3
1698 0		1705 5		1833 9		1837 2	
	14 0		12 7		9 6		10 9
1712 0		1718 2		1843 5		1848 1	
	11 5		9 3		12 5		12 0
1723 5		1727 5		1856 0		1860 1	
	10 5		11 2		11 2		10 5
1734 0		1738 7		1867 2		1870 6	
11 20 ± 2 11		11 20 ± 2 06		11 11 ± 1 54		10 94 ± 2 52	
± 0 64		± 0 63		± 0 47		± 0 76	

en y ajoutant les périodes moyennes et les erreurs moyennes d'une détermination (l'oscillation de la période) et de la moyenne (l'incertitude de la moyenne). En étudiant cette table on reconnaît facilement qu'il n'y a pas une différence prononcée ni entre les résultats déduits de la première et de la seconde série, ni entre ceux dérivés des minima et des maxima Il en résulte que la moyenne des 44 déterminations

$$T = 11\overset{a}{\,}111 \pm 2\overset{a}{\,}030 \text{ (oscillation)},$$
$$\pm 0\,307 \text{ (incertitude)}$$

donne la valeur la plus sûre pour la longueur de la période, et *il est à remarquer que cette valeur coincide jusqu'à la dernière décimale avec celle que j'ai déduite en* 1852 de 12 époques seulement, et sans connaître alors ni les belles séries des HARRIOT, KIRCH, PLANTADE, HAGEN, STAUDACHER, SCHUBERT, HORREBOW, HEINRICH, FLAUGERGUES, TEVEL, ADAMS, PASTORFF, etc., ni les séries complètes obtenues dans le quart de siècle qui s'est écoulé depuis 1852.* Le seul moyen de fixer cette valeur plus exactement encore que je ne l'ai fait est de compléter les séries d'observations rassemblées par moi, mais personne ne l'a fait jusqu'à présent. Ceux qui se sont efforcés de la changer ne se sont basés que sur mes publications; ils ont simulé de se méfier de ma première série, et ils ont changé sans fondement ma seconde série en déplaçant quelques-unes de mes époques à la fin du dernier siècle et au commencement du siècle présent, pour intercaler une nouvelle période que personne n'a observée, et tout cela pour sauver à tout prix la période décennale que SCHWABE, SABINE et LAMONT avaient trouvée sans consulter les anciennes observations.†

La confirmation complète des résultats obtenus en 1852 est certainement d'une grande importance; mais des études nouvelles m'ont fait découvrir en outre quelques autres faits intéressants. *En premier lieu* elles montrèrent que ce n'est que la *longueur moyenne* de la période solaire qui, depuis longtemps, ne s'écarte pas de $11\frac{1}{9}$ ans, et que chaque période peut en différer de plus de deux ans. *En second lieu* elles m'ont permis de déterminer des époques moyennes pour le minimum et le maximum, et d'en déduire une autre particularité remarquable: en ajoutant aux époques de minimum et aux époques de maximum de la seconde série tour à tour

$$6T, \quad 5T, \qquad T, \quad 0, \quad -T, \qquad -5T,$$

et en prenant la moyenne des nombres résultants,‡ on trouve

1810·53 pour l'époque moyenne du minimum,
1815·10 „ „ „ „ maximum,

et on en déduit qu'en moyenne le minimum ne précède le maximum que de $4\frac{1}{2}$ ans, mais ne lui succède qu'après $6\frac{1}{2}$ ans. *En troisième lieu* j'en tirai des procédés sûrs pour étudier et représenter graphiquement la marche réelle et moyenne du phénomène solaire depuis le milieu du siècle passé jusqu'à présent Mais, pour y parvenir, il me fallait employer des nombres auxiliaires, que je nommai *nombres relatifs*, et que je dois faire connaître avant d'entrer en matière

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* Voilà la complète réalisation du Critérium de M. FAYE. Voir les *Comptes Rendus* du 30 juillet 1877.

† M. SCHWABE adopta lui-même plus tard ma période de 11 ans. Voir, par exemple, le N° 1521 des *Astronomische Nachrichten*.

‡ On trouve $1745{\cdot}0+6\times 11{\cdot}111 = 1811{\cdot}7$, $1755{\cdot}2+5\times 11{\cdot}111 = 1810{\cdot}8$, etc.

En désignant par g le nombre des groupes de taches vus un jour quelconque sur le soleil, une tache isolée comptant pour un groupe, par f le nombre des taches contenues dans tous les groupes, nombre que j'estime approximativement proportionnel à la surface tachetée, et par k un coefficient dépendant de l'observateur et de son instrument, et déduit d'observations correspondantes, en supposant ce coefficient égal à l'unité pour moi et pour le grossissement 64 d'un FRAUNHOFER de 4 pieds—je pose

$$r = k\,(f+10g),$$

et je nomme r le *nombre relatif* de ce jour La moyenne de tous les nombres relatifs appartenant au même mois ou à la même année donne le nombre relatif du mois ou de l'année, et la courbe dont les ordonnées sont proportionnelles à ces nombres relatifs, et dont les abscisses sont proportionnelles au nombre des mois ou des années écoulées, est la *courbe des taches* représentant la marche du phénomène C'est de cette manière que j'ai construit sur le diagramme ci-joint la courbe mensuelle pour les années 1831 à 1875 et la courbe annuelle* pour les années 1745 à 1875, mais quoique ces courbes donnent une image fidèle de la marche générale du phénomène, il y a quantité d'études pour lesquelles il est beaucoup plus préférable de posséder un tableau complet des nombres relatifs mensuels, et j'ajoute donc une telle table pour les années 1749 à 1876, en exposant les principes suivis pour sa construction.

Pour la dernière cinquantaine d'années on dispose d'une quantité d'observations telle qu'il n'y a pas d'incertitude nuisible pour les moyennes mensuelles des nombres relatifs, mais pour les années précédentes il y a, au contraire, nombre de mois où les observations existantes ne suffisent pas à ce but, de sorte qu'il faut interpoler pour avoir une série complète Pour cette interpolation j'ai adopté la méthode suivante —Je préparai pour une suite d'années (par exemple, pour une dizaine) un grand tableau de papier carré, dont la base correspondait aux mois successifs de ces années ; j'y introduisis les moyennes sûres et les moyennes incertaines comme ordonnées, mais en distinguant les points obtenus par les unes des points obtenus par les autres; je construisis une courbe passant par les premiers points et s'approchant autant que possible des autres, et j'inscrivis dans la table des moyennes sûres, au lieu de chaque moyenne douteuse, la moyenne entre cette dernière et l'ordonnée correspondante de la courbe. Ayant complété de cette manière la série des moyennes mensuelles, je lui en substituai encore une autre pour compenser ses irrégularités accidentelles sans effacer ses irrégularités systématiques. Je calculai la moyenne de chaque suite de douze nombres (janvier à décembre, février à janvier, mars à février, etc.), et encore la moyenne de chaque suite de deux de ces moyennes, et je considérai cette dernière moyenne comme *nombre relatif compensé* du mois moyen (juillet, août, etc.). C'est la série de ces nombres compensés que l'on trouve inscrite dans les tables ci-jointes, et dont j'ai fait usage pour construire la ligne pointillée dans le diagramme des années 1831 à 1875.

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* Cette courbe annuelle ne diffère essentiellement du spécimen que j'en ai donné autrefois à M CARRINGTON, et qu'il a publié dans son ouvrage classique *Observations of the Spots of the Sun*, que par l'échelle plus grande qui a permis de donner plus de détails instructifs

NOMBRES RELATIFS COMPENSÉS

Année	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Moyenne.
1749	—	—	—	—	—	—	81 6	82 8	84 1	86 3	87 8	88 7	—
50	89 0	90 2	92 3	**92 6**	88 2	83 8	83 3	81 8	78 6	75 4	72 9	69 6	**83 1**
51	66 8	64 2	59 5	54 6	51 7	48 8	46 2	45 0	46 3	47 5	47 6	47 1	52 1
52	47 2	46 4	45 3	46 4	47 8	48 0	48 2	47 8	46 0	44 1	42 1	40 9	45 9
53	38 2	36 2	36 7	35 8	35 0	32 1	28 8	25 8	22 8	19 9	18 3	17 4	28 9
54	17 1	15 8	13 9	13 0	12 7	12 3	12 6	13 4	11·0	13 9	12 7	10 7	13 5
55	9 2	8 4	**8 4**	8 8	8 5	8 9	9 7	9 6	9 4	9 4	10 0	11 1	**9 3**
56	11 4	11 4	11 3	10 6	10 6	10 6	10 3	10 9	12 4	14 1	16 0	17 1	12 2
1757	18 0	20 7	23 8	25 7	28 4	31 4	33 4	35 7	37 9	40 6	42 7	44 4	31 9
58	46 5	46 8	47 2	48 4	47 7	47 2	48 0	48 2	47 7	46 5	45 6	46 0	47 1
59	46 5	48 1	50 1	51 6	52 7	53 4	54 8	56 2	58 0	60 5	61 9	61 9	54 6
60	62 5	63 3	62 8	61 8	62 0	62 7	63 0	64 4	66 0	66 8	68 8	72 1	64 7
61	75 7	77 5	79 8	83 0	85 8	**86 5**	84 8	82 9	80 7	78 8	75 5	71 7	**80 2**
62	68 3	64 8	62 5	60 4	59 0	59 8	61 7	60 5	58 3	56 7	55 3	53 2	60 0
63	52 4	51 5	49 8	48 8	47 1	45 8	45 3	46 5	47 9	48 3	48 8	49 0	48 4
64	47 8	46 9	45 4	43 0	40 8	37 8	34 9	32 0	29 9	28 8	27 3	25 8	36 7

NOMBRES RELATIFS COMPENSÉS—*suite*

Année	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Moyenne
1765	25.3	25.2	24.6	23.6	22.5	21.4	20.4	19.3	19.1	19.0	18.6	18.1	21.4
66	16.4	14.4	12.7	12.0	11.2	**11.1**	12.0	13.5	14.5	15.9	17.2	18.6	**14.1**
67	20.6	22.9	26.0	29.3	32.9	36.4	38.9	41.5	43.1	43.7	46.1	49.9	35.9
68	53.0	55.4	57.8	60.6	63.5	67.4	70.7	71.5	72.1	75.1	77.2	77.7	66.8
69	81.2	86.2	91.5	98.1	103.8	106.1	107.3	111.9	**115.8**	114.6	112.5	111.9	**103.4**
70	111.1	110.9	109.3	105.2	102.3	101.2	98.0	91.1	85.7	84.9	88.9	93.9	98.5
71	93.6	89.0	86.1	85.4	83.5	81.9	84.3	88.8	90.1	90.5	86.9	79.5	86.6
72	77.3	77.6	75.4	72.8	70.7	67.8	64.6	60.1	58.3	56.7	54.3	53.3	65.7
1773	50.0	46.1	43.5	40.4	37.4	35.6	34.5	35.6	37.3	38.0	38.9	39.3	39.7
74	38.8	38.2	37.1	35.6	34.2	31.9	28.9	24.4	19.8	16.6	13.2	10.6	27.4
75	9.3	8.6	8.5	7.9	7.5	**7.2**	7.7	8.9	9.2	9.4	10.2	10.7	**8.8**
76	11.0	11.7	12.9	14.5	16.3	18.5	20.8	22.8	25.2	29.6	35.6	41.0	21.7
77	45.9	55.1	62.9	70.3	78.1	87.6	98.0	106.6	113.5	119.6	128.2	138.6	92.0
78	144.8	148.4	151.9	156.3	**158.5**	156.5	156.0	151.5	153.2	152.5	148.4	141.9	**151.7**
79	139.0	137.5	133.8	129.9	127.0	125.7	124.1	119.4	115.7	112.8	109.3	106.9	123.4
80	103.5	100.0	98.2	95.5	91.3	86.9	86.0	86.2	83.4	80.4	79.2	79.5	89.2
1781	79.4	78.0	75.4	71.5	69.8	69.1	66.2	62.8	60.6	58.8	55.6	51.0	66.5
82	47.0	44.5	42.9	42.0	40.4	38.7	37.4	36.3	36.0	35.0	33.2	31.4	38.7
83	30.6	29.4	27.7	26.4	25.1	23.6	22.2	20.3	18.3	17.0	15.5	14.1	22.5
84	12.3	10.8	10.0	9.7	9.8	10.0	9.9	9.6	**9.5**	9.7	10.5	11.9	**10.3**
85	13.9	15.5	16.9	19.4	22.0	23.5	25.4	28.3	31.6	36.1	42.0	46.3	26.7
86	49.6	54.5	60.7	66.7	72.6	79.3	86.9	93.4	97.5	100.9	104.4	107.9	81.2
87	111.4	115.3	119.2	122.9	125.8	129.5	132.2	133.3	136.6	138.1	136.4	137.8	128.2
88	140.6	**141.2**	140.4	139.1	136.6	132.8	129.9	128.7	127.6	127.3	128.3	127.3	**133.3**
1789	124.9	122.5	119.1	116.5	116.0	117.9	117.6	117.3	116.4	114.2	111.7	109.2	116.9
90	106.0	103.4	101.2	99.6	97.1	92.4	88.6	84.6	80.9	79.3	77.8	75.9	90.6
91	74.8	73.1	70.8	69.4	67.8	66.9	65.9	65.4	65.0	64.5	63.9	63.3	67.6
92	62.1	61.8	62.2	61.8	62.1	61.2	59.9	59.5	58.8	57.5	56.2	55.3	59.9
93	55.1	54.0	51.3	49.3	48.3	47.3	46.4	45.5	44.3	42.6	41.7	41.4	47.3
94	40.7	40.7	40.7	39.1	38.9	40.1	39.4	38.2	37.0	35.5	34.1	32.0	38.0
95	29.8	28.1	27.6	27.6	25.8	22.7	21.3	20.6	20.1	20.8	20.9	20.1	23.8
96	20.2	19.8	19.0	18.9	17.8	16.6	15.7	14.6	13.3	11.6	9.9	9.5	15.6

Nombres Relatifs Compensés—*suite*

Année	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Moyenne
1797	8 8	8 0	7 7	7 0	6 7	6 5	5 9	5 4	5 7	5 9	5 5	4 7	6 5
98	4 1	3 8	3 5	**3 2**	3 2	3 8	4 0	4 4	5 1	5 8	6 5	7 3	**4 6**
99	7 8	7 8	7 5	7 5	7 3	6 8	7 0	7 1	6 6	6 4	6 3	7 1	7 1
1800	8 0	9 6	10 9	11 7	12 4	14 0	16 2	17 8	19 3	20 8	22 8	24 3	15 6
01	25 2	26 6	28 3	30 0	32 1	33 7	34 9	36 5	37 7	38 9	40 6	42 5	33 9
02	44 4	46 1	48 2	50 5	52 6	54 3	55 7	57 3	59 3	61 2	62 8	64 2	54 7
03	65 6	66 5	67 2	68 4	69 7	70 7	71 7	72 5	73 2	73 9	74 5	74 9	70 7
04	75 1	75 5	**75 7**	75 3	74 7	73 7	72 5	71 2	69 6	67 5	64 6	61 9	**71 4**
1805	59 6	57 4	55 2	52 9	50 6	48 6	46 7	44 6	42 2	40 5	39 4	37 9	48 0
06	36 3	34 9	33 6	32 2	30 9	29 6	27 8	25 9	24 4	23 0	21 7	20 3	28 4
07	18 9	17 5	15 8	14 1	12 4	10 4	8 9	8 1	7 4	6 8	6 4	6 5	11 1
08	6 3	5 9	5 9	6 1	6 3	7 2	8 0	8 5	8 7	8 3	7 7	7 2	7 2
09	6 8	6 2	5 4	4 7	4 0	3 0	2 2	1 6	1 1	1 0	0 8	0 4	3 1
10	0 1	0 1	0 0	0 0	0 0	0 0	0 0	**0 0**	0 0	0 0	0 0	0 0	**0 0**
11	0 0	0 3	0 5	0 6	1 3	1 4	2 0	2 6	2 7	2 7	2 8	2 9	1 6
12	2 7	3 2	4 1	4 2	4 5	5 1	5 0	4 8	5 1	5 9	6 8	7 3	4 9
1813	8 4	8 6	8 7	10 3	11 7	12 4	13 8	14 8	15 0	15 4	15 7	15 9	12 6
14	16 2	16 0	15 5	14 9	14 4	14 3	14 3	15 0	16 7	17 9	18 4	20 3	16 2
15	22 7	25 3	27 9	29 3	30 7	33 5	35 7	37 5	41 0	44 1	46 7	47 6	35 2
16	47 3	46 6	46 5	48 2	**49 2**	47 8	46 8	46 7	47 5	47 5	45 1	43 9	**46 9**
17	44 1	45 2	45 4	43 5	42 1	41 8	41 5	39 9	34 8	31 7	33 5	34 8	39 9
18	33 8	32 4	31 4	31 4	30 8	29 9	29 9	30 0	29 3	27 9	25 8	24 3	29 7
19	24 6	24 6	23 9	23 1	23 3	24 0	23 4	22 7	22 9	22 9	23 8	22 7	23 5
20	21 2	20 7	20 4	19 2	17 6	15 9	15 4	14 8	13 8	13 4	11 7	10 2	16 2
1821	8 9	7 2	6 3	6 7	6 9	6 4	5 2	4 3	4 6	5 3	5 7	5 8	6 1
22	6 1	6 3	6 0	5 0	4 1	4 0	4 0	3 9	3 2	2 0	1 5	1 2	3 9
23	0 6	0 2	0 1	**0 1**	0 1	0 9	2 7	4 0	4 5	5 3	6 2	6 3	**2 6**
24	6 3	6 3	7 2	9 2	10 2	9 4	7 9	7 4	8 2	8 0	7 7	8 9	8 1
25	10 8	13 1	13 9	13 3	13 4	14 7	16 1	16 8	17 8	19 8	21 5	23 1	16 2
26	24 9	26 4	27 1	28 7	31 4	34 2	36 9	38 5	40 5	42 1	44 0	45 8	35 0
27	46 2	46 3	48 2	49 8	50 4	50 1	50 1	51 6	52 8	53 8	55 8	58 9	51 2
28	61 2	62 5	63 6	62 7	62 0	62 4	62 1	61 1	60 7	62 6	63 2	61 3	62 1

NOMBRES RELATIFS COMPENSÉS—*suite*

Année	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Moyenne
1829	61 9	63 5	63 5	64 6	66 1	66 9	67 6	68 8	70 2	71 1	**71 5**	70 9	**67 2**
30	68 5	65 5	64 9	66 3	67 9	69 7	70 6	69 6	69 1	67 3	63 4	61 4	67 0
31	60 1	60 4	59 6	57 0	53 8	50 0	47 1	46 6	45 3	42 5	41 5	41 3	50 4
32	39 8	36 5	33 4	31 1	28 9	27 5	26 7	24 2	20 7	17 9	15 7	13 5	26 3
33	12 0	11 6	11 6	11 2	10 3	9 2	8 2	8 0	7 9	7 6	**7 3**	7 4	**9 4**
34	7 7	7 7	7 7	8 4	10 2	12 2	13 3	13 7	14 6	17 8	21 7	24 2	13 3
35	27 4	31 9	37 9	44 5	50 4	55 1	60 2	67 0	73 8	80 5	86 7	93 2	59 0
36	99 5	103 9	105 7	107 2	109 8	116 0	125 6	132 0	136 9	138 2	138 0	139 4	119 3
1837	142 7	145 7	**146 9**	146 3	145 2	141 4	136 4	130 9	127 4	127 1	127 7	126 2	**136 9**
38	125 4	120 8	113 4	111 2	108 6	105 3	101 6	100 7	98 8	93 5	87 3	82 2	104 1
39	79 5	80 7	85 4	87 9	87 5	86 5	84 7	83 0	81 5	80 7	81 5	81 9	83 4
40	80 6	76 5	71 0	66 9	64 6	63 6	60 8	56 0	52 5	50 5	49 5	49 6	61 8
41	48 7	46 7	44 3	41 8	39 5	37 4	36 8	36 2	35 5	34 5	32 1	28 8	38 5
42	26 7	25 3	24 1	23 8	25 0	25 0	23 9	22 8	21 5	20 1	19 3	18 7	23 0
43	18 0	17 3	16 1	14 2	11 9	10 8	**10 4**	10 7	11 5	12 2	12 3	11 7	**13 1**
44	11 9	12 9	13 5	14 2	14 6	14 7	15 7	17 6	20 0	22 7	25 7	28 3	19 3
1845	29 9	30 6	31 9	33 7	34 8	37 7	40 6	41 4	42 7	44 0	45 0	46 9	38 3
46	49 0	50 6	54 7	58 7	60 1	61 2	62 5	63 2	63 8	63 8	63 4	64 8	59 6
47	65 9	69 8	75 6	83 0	91 5	96 7	102 5	109 3	113 1	116 6	120 3	123 0	97 4
48	128 2	**131 5**	128 6	124 1	121 1	122 2	124 2	124 9	125 2	124 5	123 4	120 7	**124 9**
49	116 4	110 9	107 6	104 8	101 7	98 5	92 6	87 6	85 2	82 8	78 8	77 7	95 4
50	75 6	74 0	73 7	73 4	71 5	68 1	66 4	67 0	66 9	66 7	67 2	67 0	69 8
51	66 6	66 3	65 3	64 2	63 7	64 0	64 2	62 3	60 6	60 8	60 9	59 7	63 2
52	59 4	58 9	57 0	55 9	56 2	55 3	53 1	50 9	48 9	47 2	45 6	44 5	52 7
1853	44 4	44 9	45 2	44 0	41 9	40 0	38 0	35 9	34 3	32 7	31 4	30 1	38 5
54	28 2	25 7	23 7	22 0	20 7	20 6	20 4	20 0	19 4	18 4	16 9	15 5	21 0
55	14 1	12 8	11 4	10 4	9 2	7 5	6 2	5 5	4 5	3 9	3 5	**3 2**	**7 7**
56	3 3	3 6	3 9	3 9	3 8	4 1	4 8	5 5	5 8	6 2	7 6	9 2	5 1
57	10 4	11 6	13 7	16 8	19 3	21 5	23 8	26 0	29 3	32 6	34 3	36 0	22 9
58	38 6	41 7	44 8	48 5	51 4	53 5	56 7	60 7	64 3	67 6	71 7	75 5	56 2
59	78 9	82 6	85 9	87 9	90 8	93 2	93 7	93 7	94 0	93 8	93 9	95 4	90 3
60	97 2	**97 9**	97 0	95 4	94 4	95 1	94 9	93 7	93 3	94 5	93 6	90 6	**94 8**

Nombres Relatifs Compensés—*suite*

Année	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Moyenne
1861	88 1	85 8	84 5	83 1	80 3	77 8	77 2	76 7	73 7	69 5	67 9	68 1	77 7
62	67 7	66 7	65 3	63 7	62 5	60 8	58 5	57 6	58 2	58 6	57 6	55 3	61 0
63	51 9	49 6	47 1	45 2	44 5	44 0	44 4	44 4	44 0	43 8	43 0	43 2	45 4
64	44 8	46 0	46 6	46 6	47 2	47 5	46 6	45 9	44 4	43 0	42 5	41 3	45 2
65	39 1	37 2	36 2	35 2	33 2	31 1	29 8	29 0	28 4	27 2	25 9	24 2	31 4
66	22 8	21 0	19 4	18 7	17 9	16 8	15 0	12 1	9 9	8 7	7 8	6 8	14 7
67	5 9	5 4	52	5 3	5 3	6 3	7 9	9 2	10 5	12 6	14 9	17 1	88
68	19 3	21 5	24 2	27 6	31 7	35 5	39 2	42 9	45 8	47 0	50 4	56 9	36 8
1869	61 4	64 5	68 0	69 4	70 1	72 4	74 6	77 6	84 3	93 7	101 7	105 8	78 6
70	110 0	116 2	121 6	127 5	134 0	138 0	139 6	140 5	140 2	139 6	138 5	135 4	131 8
71	132 3	129 3	125 1	120 4	116 3	112 9	110 8	110 3	107 8	103 0	98 9	98 0	113 8
72	98 9	98 3	99 0	101 0	101 9	101 9	102 0	101 8	101 6	100 9	97 3	92 1	99 7
73	87 8	85 2	81 4	75 4	70 7	67 8	65 2	62 3	58 4	54 4	52 4	52 0	67 7
74	51 8	51 5	50 4	49 1	47 4	45 5	42 7	39 0	36 8	36 1	34 6	32 7	43 1
75	29 8	25 5	22 5	20 5	19 3	17 9	17 1	16 8	16 3	15 1	13 7	12 5	18 9
76	11 7	11 6	11 7	12 0	11 8	11 4	—	—	—	—	—	—	—

La construction de cette table des nombres compensés pour les années 1749 à 1876 m'a pris un temps énorme, mais je crois que sa valeur est en bonne proportion avec la peine qu'elle m'a coûtée, et qu'on doit en faire usage dès à présent pour toutes les recherches qui sont de son ressort Je publie cette table pour donner aux autres scrutateurs une plus grande facilité et une plus grande sûreté dans leurs comparaisons, sans prétendre à autre chose qu'à des intérêts modérés de mon capital. on pourrait la nommer *Série de R Wolf*, pour m'en assurer la propriété *

Pour donner un exemple d'une étude basée sur ma série j'ajoute ma nouvelle détermination de la fréquence moyenne des taches durant une période, par laquelle mon fragment d'une courbe moyenne, approuvé en 1870, se trouve complété et corrigé Je superpose les courbes représentant les diverses périodes, de façon que les minima et que les maxima se rencontrent, je cherche dans les deux cas la courbe moyenne,* je place ces deux courbes moyennes de manière que la distance du minimum de la première et du maximum de la seconde corresponde à la différence $1815\ 10-1810\ 53=4^{\mathrm{a}}\cdot 57=4^{\mathrm{a}}\ 7^{\mathrm{m}}$, et j'en prends encore une fois la moyenne Les 133 ordonnées mensuelles de cette dernière courbe sont inscrites dans la table ci-jointe, et il va sans dire que l'on peut en faire usage pour reconstruire cette courbe moyenne

---

* On pourrait se moquer de cette prétention, mais puisqu'il existe des auteurs sans conscience on est forcé de défendre sa propriété, et je regrette de ne pas l'avoir déjà fait dans d'autres cas

Courbe Moyenne

11 11	16 94	39 20	69 96	90 16	93 47	77 08	59 73
11 15	18 01	41 31	72 34	91 92	92 86	75 22	58 22
11 38	19 21	43 37	74 61	93 25	92 01	73 39	57 27
11 62	20 52	45 52	77 09	94 14	91 22	71 46	56 53
11 85	22 06	47 75	78 78	94 68	90 57	69 23	55 78
12 05	23 56	50 15	80 37	95 45	89 54	67 16	54 96
12 42	25 86	52 70	81 65	96 64	87 84	66 06	53 65
13 13	27 51	55 57	82 80	97 76	85 72	65 36	51 62
13 92	29 52	58 83	83 99	97 74	83 46	64 55	49 93
14 57	32 02	62 04	85 05	96 90	81 69	63 55	48 28
15 15	34 67	65 10	86 36	95 97	79 94	62 42	46 50
16 09	37 00	67 69	88 09	94 48	78 36	61 22	44 15

---

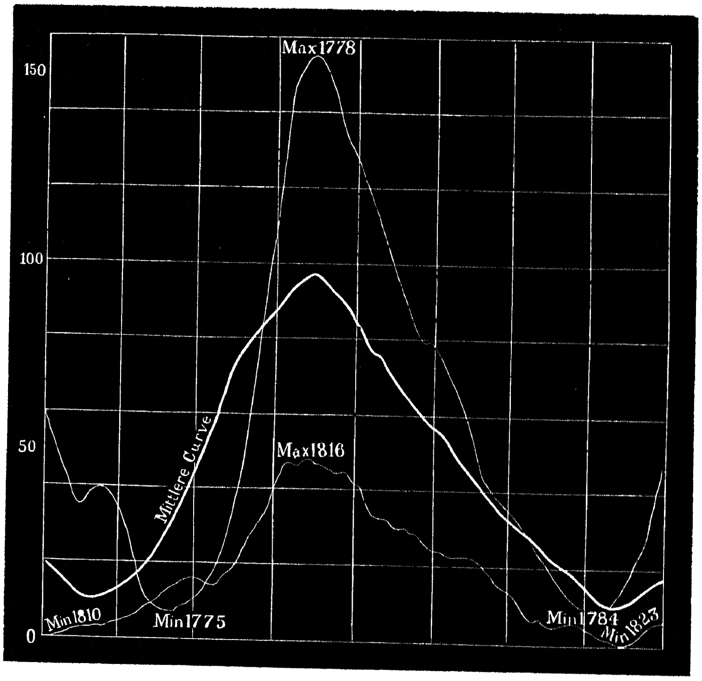
* Je dois dire que je n'exécute pas ces opérations graphiquement, mais arithmétiquement avec les nombres donnés dans la table Le schéma ci-joint donne un fragment de la disposition des calculs faits pour construire la courbe moyenne dérivée des minima superposés, je ne pense pas qu'il soit nécessaire de le commenter

12 0	11 2	1776 VI	11 1	12 0	13 5
7 9	7 5	1775 VI	7 2	7 7	8 9
9 9	9 6	1784 IX	9 5	9 7	10 5
3 8	3 5	1798 IV	3 2	3 2	3 8
0 0	0 0	1810 VIII	0 0	0 0	0 0
0 2	0 1	1823 IV	0 1	0 1	0 9
7 9	7 6	1833 XI	7 3	7 4	7 7
11 9	10 8	1843 VII	10 4	10 7	11 5
3 9	3 5	1855 XII	3 2	3 3	3 6
5 9	5 4	1867 III	5 2	5 3	5 3
6 34	5 92	Moyenne	5 72	5 94	6 57

COURBE MOYENNE—*suite*

43 92	36 63	31 02	24 70	20 56	15 87	11 36
42 46	35 90	30 30	23 85	19 67	15 16	
40 94	34 84	29 47	23 23	18 86	14 12	
39 39	33 69	28 35	22 70	17 85	13 18	
38 39	32 79	27 09	22 04	17 29	12 41	
37 54	31 94	25 66	21 34	16 62	11 80	

La gravure ci-jointe donne en petite échelle une idée de cette courbe et de ses écarts des courbes extrêmes réelles observées jusqu'à présent, celle du minimum 1775 au minimum 1784, et celle du minimum 1810 au minimum 1823



La comparaison de la courbe moyenne avec les courbes réelles m'a déjà donné plusieurs résultats intéressants,* mais je préfère d'en parler une autre fois, et de finir aujourd'hui par quelques remarques sur la connexion entre la fréquence des taches solaires et les variations de la déclinaison magnétique.

---

* Voir le N° 42 de mes *Mittheilungen.*

Comme j'avais réussi en 1852 à améliorer la formule déduite par LAMONT pour ces variations, en y introduisant la période solaire de $11\frac{1}{9}$ ans, ce simple fait me parut un indice certain de la relation intime entre les variations v et les taches ou les nombres relatifs r, et je pensai bientôt que ces deux quantités v et r devaient être regardées comme deux enregistrements des effets d'une même cause inconnue; mais dans ce cas il devrait être possible de transformer l'une des deux dans l'autre, comme on transforme d'autres lectures faites sur deux échelles différentes—c'est-à-dire, de trouver une formule

$$v = \alpha + \beta r,$$

où α et β désignent deux constantes à déduire des deux séries d'après la méthode des moindres carrés C'est de cette manière que je trouvai pour Munich la formule

$$v = 6' \, 27 + 0' \, 051 \; r,$$

qui représente non-seulement fort bien * la série des variations observées à Munich de 1835 à 1850, mais qui me permit de calculer d'avance à la fin de chaque année successive la variation correspondante, en y introduisant pour r la valeur conclue des observations solaires, et de la comparer plus tard à la variation observée L'accord fut si satisfaisant qu'il prouva la justesse de ma supposition, et qu'il m'engagea à déduire des formules analogues pour d'autres stations, entre autres la formule

$$v = 5' \, 80 + 0' \, 045 \; r$$

pour Prague, qui possède la série la plus longue et la plus homogène de variations observées En supposant qu'on pût appliquer sans aucun changement cette dernière formule aux années précédentes, j'en déduisis les variations pour les années 1745 à 1839, et c'est cette série que j'ai représentée dans le diagramme par une ligne pointillée dont la continuation correspond aux variations observées à Prague de 1840 à 1875 J'ai représenté dans le même diagramme les variations observées autrefois à Mannheim, Paris, Londres et Gottingen, et l'on voit du premier coup d'œil que les maxima et les minima de ces courbes† coincident à peu près avec les maxima et les minima de la courbe pointillée, quoique ces séries anciennes aient été obtenues avec des

---

* Voir le N° 9 de mes *Mittheilungen*

† Les courbes elles-mêmes ne peuvent coincider parce que l'échelle n'est pas la même

appareils très-imparfaits.* Cette concordance est d'autant plus remarquable qu'elle concerne entre autres les époques critiques de 1784–85, 1787–88 et 1829–30, où la courbe solaire s'écarte le plus de la courbe moyenne, de sorte qu'elle prouve que *les variations magnétiques subissent les mêmes perturbations que le développement des taches solaires* Et si l'on voit d'autre part que la courbe magnétique de Prague suit depuis 1840 jusqu'à 1875 la courbe solaire non-seulement en général, mais dans les plus petits détails, on est autorisé à déclarer que *l'on trouve dans les changements de la fréquence des taches solaires et de la variation magnétique deux phénomènes dépendants ou l'un de l'autre ou plutôt de la même cause cosmique*, et que chercher les autres effets de cette cause inconnue, et trouver ainsi peut-être plus tard la cause elle-même, n'est pas un rêve d'une tête légère, mais bien un devoir scientifique

---

* On peut toutefois en excepter la série de Gottingen

A LIST OF PERSONS

TO WHOM

THE MEDALS OR TESTIMONIALS OF THE SOCIETY

HAVE BEEN ADJUDGED

1823

June 13. Charles Babbage, Esq.

The Gold Medal—For his Invention of an Engine for computing and printing Mathematical Tables.

Professor Johann Friedrich Encke.

The Gold Medal.—For his Investigations relative to the Comet which bears his name

Charles Rumker, Esq.

The Silver Medal—For his Re-discovery of Encke's Comet in 1822

M Jean Louis Pons

The Silver Medal.—For his Discovery of Two Comets in 1822.

1826

Feb 7 J F. W. Herschel, Esq and James South, Esq.

The Gold Medal, each.—For their important Researches on the subject of Multiple Stars.

Feb 10 Professor Struve.

The Gold Medal.—For his important Researches on the subject of Multiple Stars.

1827

Feb. 2 Francis Baily, Esq.

The Gold Medal—For his "New Tables for determining the places of 2,881 Stars."

William Samuel Stratford, Esq.

The Silver Medal—For his Superintendence of the Computation of "New Tables for determining the places of 2,881 Stars."

Feb 5 Colonel Mark Beaufoy

The Silver Medal.—For his valuable Collection of Observations, particularly those of the Eclipses of *Jupiter's* Satellites.

1828.
Jan. 11. Sir THOMAS MACDOUGALL BRISBANE, K.C.B.
The Gold Medal.—For his Establishment of an Observatory, and for an important series of Observations made at Paramatta.

JAMES DUNLOP, Esq.
The Gold Medal.—For his Observations of the Nebulæ of the Southern Hemisphere.

Feb. 4. Miss CAROLINE HERSCHEL.
The Gold Medal.—For her recent reduction, to January 1800, of the Nebulæ discovered by Sir WILLIAM HERSCHEL.

1829.
Jan. 9. Rev. WILLIAM PEARSON.
The Gold Medal.—For his work entitled "An Introduction to Practical Astronomy."

Professor BESSEL.
The Gold Medal.—For his Zone Observations.

Professor SCHUMACHER.
The Gold Medal.—For the Publication of his various Astronomical Tables, and the "Astronomische Nachrichten."

1830.
Jan. 8. Mr. WILLIAM RICHARDSON.
The Gold Medal.—For his Investigation of the Constant of Aberration.

Professor ENCKE.
The Gold Medal.—For the New Berlin Ephemeris.

1831.
Jan. 14. Captain KATER.
The Gold Medal.—For his Invention of the Vertical Floating Collimator.

Baron DAMOISEAU.
The Gold Medal.—For his Memoir upon the Theory of the Moon, and for his Lunar Tables.

1833.
Jan. 11. Professor AIRY.
The Gold Medal.—For his Discovery of the long Inequality of *Venus* and the Earth.

1835.
Jan. 9. Lieutenant JOHNSON.
The Gold Medal.—For his Catalogue of 606 Southern Stars.

1836.
Jan. 8. Sir JOHN F. W. HERSCHEL.
The Gold Medal.—For his Catalogue of Nebulæ, printed in the "Philosophical Transactions" for 1833.

1837
Jan. 13. Professor ROSENBERGER.
The Gold Medal.—For his Investigations relative to HALLEY'S Comet.

1839
Jan. 11 Hon. JOHN WROTTESLEY.
The Gold Medal —For his Catalogue of the Right Ascensions of 1,318 Stars

1840
Jan. 10. M. JEAN PLANA
The Gold Medal —For his Work, entitled "Théorie du Mouvement de la Lune"

1841
Jan. 8 Professor BESSEL.
The Gold Medal —For his Observations and Researches on the Parallax of 61 *Cygni*.

1842
Jan. 14 M HANSEN.
The Gold Medal —For his Researches in Physical Astronomy

1843
Jan 13 FRANCIS BAILY, Esq.
The Gold Medal —For his Experiments to determine the Mean Density of the Earth in repetition of what is generally termed the "Cavendish Experiment"

1845
Jan. 10 Captain WILLIAM HENRY SMYTH, R N
The Gold Medal —For his "Bedford Catalogue," forming the second part of his work entitled "Celestial Cycle."

1846
Jan. 9 GEORGE BIDDELL AIRY, Esq , Astronomer Royal
The Gold Medal —For his Reduction of the Observations of Planets made at the Royal Observatory, Greenwich, from 1750 to 1830.

1848
Jan. 14 *Testimonials were awarded to*
GEORGE BIDDELL AIRY, Esq., Astronomer Royal.
For the Lunar Reductions recently made at Greenwich

JOHN COUCH ADAMS, Esq.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Professor ARGELANDER.
For his Catalogue of Stars.

1848
Jan 14. George Bishop, Esq
For the Foundation of an Observatory leading to various Astronomical Discoveries.

Lieut.-Col George Everest
For his Measurement of the Indian Arc.

Sir John F W Herschel.
For his Work on the Southern Hemisphere.

Professor P A. Hansen
For his Lunar Theory and Computation of Perturbations.

M. Hencke.
For his Discovery of two Planets, *Astræa* and *Hebe*.

John Russell Hind, Esq
For his Discovery of Two Planets, *Iris* and *Flora*

M U J Le Verrier.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Sir John Lubbock.
For his Researches in the Theory of Perturbations.

M. M Weisse.
For his Catalogue of Stars in Bessel's Zones.

1849
Feb 9 William Lassell, Esq.
The Gold Medal—For the construction of his Equatoreal Instrument and for the Discoveries made with it.

1850
Feb 8 M Otto Von Struve
The Gold Medal.—For his Paper on the Constant of Precession.

1851
Feb 15 Dr Annibale de Gasparis
The Gold Medal—For the Discovery of three Planets, *Hygeia*, *Parthenope*, and *Egeria*.

1852
Feb 13 Dr. C. A. F. Peters
The Gold Medal—For his Papers on the Parallax of the Fixed Stars, and on the Constant of Nutation.

1853
Feb. 11. JOHN RUSSELL HIND, Esq
The Gold Medal—For the Discovery of eight Planets, and other Astronomical Discoveries.

1854.
Feb. 10 M. CHARLES RUMKER.
The Gold Medal—For his Catalogue of 12,000 Stars, and for other Astronomical Services.

1855
Feb. 9 Rev. W. R. DAWES.
The Gold Medal.—For his Astronomical Labours generally.

1856
Feb. 8. ROBERT GRANT, Esq, M.A
The Gold Medal.—For his "History of Physical Astronomy."

1857
Feb. 13. M. SCHWABE.
The Gold Medal.—For his Discovery of the Periodicity of the Solar Spots.

1858
Feb. 12. Rev. ROBERT MAIN, M A.
The Gold Medal.—For his various Contributions to the *Memoirs* of the Society.

1859
Feb. 11. R. C CARRINGTON, Esq.
The Gold Medal.—For his "Redhill Catalogue of 3,735 Circumpolar Stars."

1860
Feb. 10 Professor P. A. HANSEN.
The Gold Medal.—For his Lunar Tables

1861
Feb. 8. M. HERMANN GOLDSCHMIDT.
The Gold Medal.—For his Discovery of thirteen of the Minor Planets, and other Astronomical Discoveries

1862
Feb. 14 WARREN DE LA RUE, Esq
The Gold Medal.—For his Astronomical Researches, and especially for his Application of Photography.

1863
Feb. 13. Professor ARGELANDER.
The Gold Medal—For his Survey of the Northern Heavens.

1865 Feb. 10.	Professor G. P. Bond. *The Gold Medal*.—For his work on the Comet of Donati, and other Astronomical Researches.
1866 Feb. 9.	Professor Adams. *The Gold Medal*.—For his Contributions to the Development of the Lunar Theory.
1867 Feb. 8.	W. Huggins, Esq., and Professor Miller. *The Gold Medal*.—For their Researches in Astronomical Physics.
1868 Feb. 14.	M. Leverrier. *The Gold Medal*.—For his Planetary Tables.
1869 Feb. 12.	E. J. Stone, Esq. *The Gold Medal*.—For his Rediscussion of the Transit of *Venus* in 1769, and his other contributions to Astronomy.
1870 Feb. 11.	M. Delaunay. *The Gold Medal*.—For his "Théorie de la Lune."
1872 Feb. 9.	Signor Schiaparelli. *The Gold Medal*.—For his Researches on the Connexion between the Orbits of Comets and Meteors.
1874. Feb. 13.	Professor Simon Newcomb. *The Gold Medal*.—For his Tables of *Neptune* and *Uranus*, and other contributions to Mathematical Astronomy.
1875 Feb. 12.	Professor D'Arrest. *The Gold Medal*.—For his work entitled "Siderum Nebulosorum Observationes Havnienses, institutæ in Specula Universitatis per tubum sedecimpedalem Merzianum, ab anno 1861 ad annum 1867," and other Astronomical Works.
1876 Feb. 11.	M. Le Verrier. *The Gold Medal*.—For his Investigations of the Theories of *Jupiter*, *Saturn*, *Uranus*, and *Neptune*, and for his Tables of *Jupiter* and *Saturn*.

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PAPERS.

I On a General Method of treating the Lunar Theory. By E Neison, Esq

§ 1

The present Memoir contains the theoretical foundation on which has been based a complete analytical development of the Lunar Theory As the work itself is far advanced it has been deemed advisable to detail the method by which it is being effected. Although it involves no new principle, the method by which the development is being effected consists of an entirely new application of known processes. Devised with the view of simplifying the older methods of treating the lunar theory, it has been found to very much decrease the labour involved, and in particular lessen the mental anxiety inseparable from the older systems

Plana, Pontécoulant, and Delaunay have alone obtained an algebraical solution of the lunar theory, and it is this alone which is now considered The methods employed by Plana and Pontécoulant may be said to be the repeated application of the following operation A lengthy series of cosines or sines with algebraical coefficients is multiplied by a similar series of cosines or sines with different algebraical coefficients. In the product all similar terms are united together, and the algebraical coefficients reduced to their simplest terms, by the repeated multiplication and addition of numerical fractions There are many objections to this method. If any error be made in effecting the numerous multiplications and additions and reductions of the different complex algebraical coefficients, this error is absolutely irremediable, and unless every step in the work is performed again it is undetectable. Again, as it is impracticable to effect the complete multiplication of such series of cosines or sines, it is necessary to neglect all terms whose algebraical coefficient exceeds some fixed order In fact, generally at least nine-tenths, but often nearly ninety-nine hundredths of these terms must be omitted But if one single term be omitted which ought to be retained, the whole work is vitiated and must be reperformed , and, as in the previous case, it is impossible to ascertain whether any error has been thus made without undertaking the whole work over again If any error be made in any of these operations, it will usually destroy the trustworthiness of the whole theory, because it cannot be said what terms are affected by the error, or to what extent There are of course exceptions to this, as errors made in certain portions of the work admit of easy rectification In general, however, an error in the formation of any of these products will vitiate the accuracy of the greater number of coefficients, to the same order as itself It is from this cause that the great difficulty arises in dealing with the lunar theory on the old system Every step has to be verified, reverified, and checked with the greatest care Every process has to be examined with the minutest attention to see that no term which may be wanted is omitted. This involves an amount of labour and worry which it is difficult to realise without having experienced it

Delaunay's original and magnificent method of treating the lunar theory is not open to the same objections to the same extent If it presents still greater facilities for making errors, it affords also the means of discovering them and the possibility of rectifying the errors when discovered. Unfortunately this method, so admirable in theory, involves immensely increased work, and the lunar theory as carried out by Delaunay must have taken quadruple the labour which would have been necessary to have obtained the same end by the methods employed by either Plana or Pontécoulant. In other respects the system employed by Delaunay may be said to be based on the same principle as that of his two predecessors, and throughout every term has a special algebraical coefficient of more or less complexity Every operation performed with this coefficient must be verified and reverified, checked and rechecked, to secure absolute immunity from arithmetical errors Further, should an error escape detection, the process of rectifying the error is a work of very considerable labour and trouble

In the lunar theory as developed by each of these three great astronomers the point which presents the greatest difficulty to subsequent workers in the same field is the impracticability of verifying the final results. In Plana's work this is almost impossible without working through the whole process. In Pontécoulant's results the same difficulty is to be found Finally, in Delaunay's development the task is one of great labour, although, from the care he has taken, one which is perfectly feasible In each of these three methods a specific algebraical coefficient is given to every term If, then, an error is discovered in any term it is necessary to proceed through every subsequent step and correct each of these to allow for the effect of the error If the error be of any importance this is equivalent, in the theories of Plana and Pontécoulant, to performing the work over again, and even in Delaunay's work involves much labour

One of the principal differences between the present system and those of Plana, Pontécoulant, and Delaunay is that this difficulty is overcome Every argument is represented by a fixed symbol which indicates not only its origin, but the method by which it enters the theory Every step is performed with these general symbols, and when the final result is obtained it presents the solution as an explicit function of these general symbols It only remains to substitute for these symbols their particular values, and reduce the resulting coefficient to its simplest terms, and the complete value is at once obtained As no multiplication or addition of complex algebraical coefficients occur except in this final result, it is only at this point that this laborious operation, with its incessant verifications, comes into play Moreover, in the great majority of cases, any error in this portion will affect the single term in which it is made and no other In any instance any error which may be made can be rectified without the slightest trouble Every single constituent of any term indicates on its face both how and where it arose. Therefore there can be no difficulty in ascertaining whether any term has been omitted which should not have been omitted, and if so its place can be supplied in the final result by mere inspection Every single term in the final result admits of separate verification or determination Any alteration made in any coefficient whatever which enters into the theory can be made in the final result without trouble These are considerable advantages, and against them the solitary disadvantage seems to be that the final expression for the lunar coordinates is of considerably greater length

In concluding this statement it only remains to add that the development of the theory has been carried completely to the seventh order, and certain terms to the eighth order, or practically one order beyond Delaunay. The theoretical foundation has been so constructed to enable the results to be pushed to the eighth order completely

§ 2

Employing the usual notation, the differential equations to the motion of the Moon around the Earth are (Pontécoulant, *Théorie Analytique du Système du Monde*, tome 1, p. 205)

$$\frac{d^2x}{dt^2}+\mu\frac{x}{r^3}=\frac{dR}{dx},\qquad \frac{d^2y}{dt^2}+\mu\frac{y}{r^3}=\frac{dR}{dy},\qquad \frac{d^2z}{dt^2}+\mu\frac{z}{r^3}=\frac{dR}{dz}\tag{1}$$

The variable r is the radius vector of the Moon, and therefore

$$r^2=x^2+y^2+z^2\tag{2}$$

Differentiating with respect to t,

$$\frac{d(r^2)}{dt}=2r\frac{dr}{dt}=2\left\{x\frac{dx}{dt}+y\frac{dy}{dt}+z\frac{dz}{dt}\right\}\tag{3}$$

Again differentiating R with respect to t in so far as the coordinates of the Moon enter into R,

$$\left(\frac{dR}{dt}\right)=\frac{dR}{dx}\frac{dx}{dt}+\frac{dR}{dy}\frac{dy}{dt}+\frac{dR}{dz}\frac{dz}{dt}\tag{4}$$

Multiplying the first of equations (1) by $2\frac{dx}{dt}$, the second by $2\frac{dy}{dt}$, and the third by $2\frac{dz}{dt}$, and adding, they form

$$2\left\{\frac{d^2x}{dt^2}\frac{dx}{dt}+\frac{d^2y}{dt^2}\frac{dy}{dt}+\frac{d^2z}{dt^2}\frac{dz}{dt}\right\}+2\frac{\mu}{r^3}\left\{x\frac{dx}{dt}+y\frac{dy}{dt}+z\frac{dz}{dt}\right\}=2\left\{\frac{dR}{dx}\frac{dx}{dt}+\frac{dR}{dy}\frac{dy}{dt}+\frac{dR}{dz}\frac{dz}{dt}\right\}=2\left(\frac{dR}{dt}\right)\tag{5}$$

Substituting in this equation the values in equations (3) and (4) it becomes

$$2\left\{\frac{d^2x}{dt^2}\frac{dx}{dt}+\frac{d^2y}{dt^2}\frac{dy}{dt}+\frac{d^2z}{dt^2}\frac{dz}{dt}\right\}+2\frac{\mu}{r^2}\frac{dr}{dt}=2\left(\frac{dR}{dt}\right)$$

Integrating

$$\left(\frac{dx}{dt}\right)^2+\left(\frac{dy}{dt}\right)^2+\left(\frac{dz}{dt}\right)^2-2\frac{\mu}{r}+c=2\int\left(\frac{dR}{dt}\right)dt.\tag{6}$$

Next differentiate the equation (3) and it becomes

$$\frac{d^2(r^2)}{dt^2}=2\left\{x\frac{d^2x}{dt^2}+y\frac{d^2y}{dt^2}+z\frac{d^2z}{dt^2}+\left(\frac{dx}{dt}\right)^2+\left(\frac{dy}{dt}\right)^2+\left(\frac{dz}{dt}\right)^2\right\} \tag{7}$$

If the first of equations (1) be multiplied by x, the second by y, and the third by z, and these three products added to equation (6), it becomes

$$x\frac{d^2x}{dt^2}+y\frac{d^2y}{dt^2}+z\frac{d^2z}{dt^2}+\left(\frac{dx}{dt}\right)^2+\left(\frac{dy}{dt}\right)^2+\left(\frac{dz}{dt}\right)^2-\frac{\mu}{r}+c=2\int\left(\frac{dR}{dt}\right)dt+\left\{x\frac{dR}{dx}+y\frac{dR}{dy}+z\frac{dR}{dz}\right\} \tag{8}$$

Substitute in this the value given by (7) and it becomes

$$\frac{1}{2}\frac{d^2(r^2)}{dt^2}-\frac{\mu}{r}+c=2\int\left(\frac{dR}{dt}\right)dt+\left\{x\frac{dR}{dx}+y\frac{dR}{dy}+z\frac{dR}{dz}\right\} \tag{9}$$

Now

$$\left\{x\frac{dR}{dx}+y\frac{dR}{dy}+z\frac{dR}{dz}\right\}=\left\{x\frac{dr}{dx}+y\frac{dr}{dy}+z\frac{dr}{dz}\right\}\frac{dR}{dr}, \tag{10}$$

and from the value of r in (3)

$$x\frac{dr}{dx}=\frac{x^2}{r},\qquad y\frac{dr}{dy}=\frac{y^2}{r},\qquad z\frac{dr}{dz}=\frac{z^2}{r}$$

Therefore, substituting these values, (10) becomes

$$\left\{x\frac{dR}{dx}+y\frac{dR}{dy}+z\frac{dR}{dz}\right\}=r\frac{dR}{dr}, \tag{11}$$

whence (9) reduces to

$$\frac{1}{2}\frac{d^2(r^2)}{dt^2}-\frac{\mu}{r}+c=r\frac{dR}{dr}+2\int\left(\frac{dR}{dt}\right)dt \tag{12}$$

Assume as a new dependent variable

$$v=\tan^{-1}\frac{y}{x} \tag{13}$$

Differentiate with respect to t, and

$$\frac{dv}{dt}=-\frac{y}{y^2+x^2}\frac{dx}{dt}+\frac{x}{x^2+y^2}\frac{dy}{dt}=-\frac{1}{r^2-z^2}\left\{y\frac{dx}{dt}-x\frac{dy}{dt}\right\} \tag{14}$$

Next differentiating with respect to x, and y,

$$y\frac{dv}{dx}=-\frac{y^2}{y^2+x^2},\qquad x\frac{dv}{dy}=\frac{x^2}{y^2+x^2} \tag{15}$$

Multiply the first of equations (1) by y, and subtract from it the second multiplied by x,

$$y\frac{d^2x}{dt^2}-x\frac{d^2y}{dt^2}=y\frac{dR}{dx}-x\frac{dR}{dy}, \tag{16}$$

whence

$$\frac{d}{dt}\left\{y\frac{dx}{dt}-x\frac{dy}{dt}\right\}=\left\{y\frac{dv}{dx}-x\frac{dv}{dy}\right\}\frac{dR}{dv} \tag{17}$$

Substituting in this equation the values in (14) and (15), it becomes

$$-\frac{d}{dt}\left\{(r^2-z^2)\frac{dv}{dt}\right\}=-\frac{dR}{dv}$$

Integrating, the last equation becomes

$$(r^2-z^2)\frac{dv}{dt}=h+\int\frac{dR}{dv}dt \tag{18}$$

For the third dependent variable assume

$$\lambda=\sin^{-1}\frac{z}{r}, \tag{19}$$

and suppose

$$\psi=r\sin\lambda=z \tag{20}$$

Therefore, substituting this value in the third equation of (1), it becomes

$$\frac{d^2\psi}{dt^2}+\mu\frac{\psi}{r^3}=\frac{dR}{d\psi} \tag{21}$$

From the three new variables which have been assumed,

$$r=\sqrt{\{x^2+y^2+z^2\}},$$

$$v=\tan^{-1}\frac{y}{x},$$

$$\psi=z,$$

the following three differential equations have been deduced —

$$\begin{aligned}\frac{1}{2}\frac{d^2(r^2)}{dt^2}-\frac{\mu}{r}+c&=r\frac{dR}{dr}+2\int\left(\frac{dR}{dt}\right)dt,\\ \frac{dv}{dt}&=\frac{1}{r^2-\psi^2}\left\{h+\int\frac{dR}{dv}dt\right\},\\ \frac{d^2\psi}{dt^2}+\mu\frac{\psi}{r^3}&=\frac{dR}{d\psi}\end{aligned} \tag{A}$$

These equations are of exactly the same form as those employed by Pontécoulant (*Système du Monde*, tome iv, p 43), and after being developed slightly further, will be employed in determining the motion of the Moon.

§ 3.

Suppose μ, or the sum of the masses of the Earth and Moon to be unity, and the disturbing function will be (Pontécoulant, *Théorie Analytique du Système du Monde*, tome iv, p 39)

$$R = \frac{m'}{\sqrt{\{(x'-x)^2+(y'-y)^2+(z'-z)^2\}}} - \frac{m'}{r'^3}(xx'+yy'+zz'), \tag{1}$$

where, as usual, x', y', z' are the rectangular coordinates of the Sun and m' and r' the mass and radius vector of the Sun

Putting S for the cosine of the angle between r and r', it can be easily shown that

$$\sqrt{\{(x'-x)^2+(y'-y)^2+(z'-z)^2\}} = \sqrt{\{r'^2+r^2-2rr'S\}}, \tag{2}$$

$$xx'+yy'+zz' = rr'S \tag{3}$$

Expanding (2) in powers of $\frac{r}{r'}$ and substituting with (3) in the value of R given by (1), it becomes

$$R = \frac{m'}{r'} + m'\frac{r^2}{r'^3}\left\{\left(\frac{3}{2}S^2-\frac{1}{2}\right)+\frac{r}{r'}\left(\frac{5}{2}S^3-\frac{3}{2}S\right)+\frac{r^2}{r'^2}\left(\frac{35}{8}S^4-\frac{15}{4}S^2+\frac{3}{8}\right)\right.$$
$$\left.+\frac{r^3}{r'^3}\left(\frac{63}{8}S^5-\frac{35}{4}S^3+\frac{15}{8}S\right)+\quad\cdot\quad\right\} \tag{4}$$

The higher powers of $\frac{r}{r'}$ can be neglected, because, being the ratio of the distances of the Sun and Moon from the Earth, it is a very small quantity.

Assume the plane of x, y to be the plane of the Earth's orbit and to be fixed, and suppose further that the Sun's latitude is always zero. This is of course equivalent to deferring for the present the consideration of the effect of the very small inequalities in latitude to which the Earth is subject. Then

$$S = \cos\lambda\cos(v-v'), \tag{5}$$

where v' is the longitude of the Sun, supposed to be counted from the same origin as the longitude of the Moon, and both supposed to be measured on the Ecliptic

Substituting for S this value, (4) becomes

$$
\begin{aligned}
\mathrm{R}=\frac{m'}{r'}+m'\Big\{&\frac{r^2}{r'^3}\Big[-\frac{1}{2}+\frac{3}{4}\cos^2\lambda\cos 2(v-v')\Big]\\
&+\frac{r^3}{r'^4}\Big[\Big(-\frac{3}{2}\cos\lambda+\frac{15}{8}\cos^3\lambda\Big)\cos(v-v')+\frac{5}{8}\cos^3\lambda\cos 3(v-v')\Big]\\
&+\frac{r^4}{r'^5}\Big[\Big(\frac{3}{8}-\frac{15}{8}\cos^2\lambda+\frac{105}{64}\cos^4\lambda\Big)\\
&\qquad+\Big(-\frac{15}{8}\cos^2\lambda+\frac{35}{16}\cos^4\lambda\Big)\cos 2(v-v')-\frac{35}{64}\cos^4\lambda\cos 4(v-v')\Big] \qquad (6)\\
&+\frac{r^5}{r'^6}\Big[\Big(\frac{15}{8}\cos\lambda-\frac{105}{16}\cos^3\lambda+\frac{315}{64}\cos^5\lambda\Big)\cos(v-v')\\
&\qquad+\Big(-\frac{35}{16}\cos^3\lambda+\frac{315}{128}\cos^5\lambda\Big)\cos 3(v-v')+\frac{63}{128}\cos^5\lambda\cos 5(v-v')\Big]\\
&+\qquad\Big\}
\end{aligned}
$$

From this expression the values of $\frac{d\mathrm{R}}{dr}$, and $\frac{d\mathrm{R}}{dv}$ can be easily obtained by direct differentiation; but although $\frac{d\mathrm{R}}{d\psi}$ could be obtained likewise in this manner, it is more conveniently formed as follows From (4)

$$\frac{d\mathrm{R}}{d\psi}=\frac{d\mathrm{R}}{dr}\frac{dr}{d\psi}+\frac{d\mathrm{R}}{d\mathrm{S}}\frac{d\mathrm{S}}{d\psi} \qquad (7)$$

From the value of r (§ 2, Eq. 2), as $\psi=z$,

$$\frac{dr}{d\psi}=\frac{\psi}{r}=\sin\lambda \qquad (8)$$

Again, from (3),

$$\frac{d\mathrm{S}}{d\psi}=-\frac{\psi}{r^2}\mathrm{S}=\frac{\sin\lambda}{r}\mathrm{S} \qquad (9)$$

Substituting these values in (7) and

$$\frac{d\mathrm{R}}{d\psi}=\sin\lambda\frac{d\mathrm{R}}{dr}-\sin\lambda\frac{\mathrm{S}}{r}\frac{d\mathrm{R}}{d\mathrm{S}}=\sin\lambda\Big(\frac{d\mathrm{R}}{dr}-\frac{\mathrm{S}}{r}\frac{d\mathrm{R}}{d\mathrm{S}}\Big) \qquad (10)$$

From (4), by differentiating,

$$\frac{d\mathrm{R}}{dr}=m'\left\{\frac{r}{r'^3}(3\,\mathrm{S}^2-1)+\frac{r^2}{r'^4}\left(\frac{15}{2}\,\mathrm{S}^3-\frac{9}{2}\,\mathrm{S}\right)+\frac{r^3}{r'^5}\left(\frac{35}{2}\,\mathrm{S}^4-15\,\mathrm{S}^2+\frac{3}{2}\right)\right.$$
$$\left.+\frac{r^4}{r'^6}\left(\frac{315}{8}\,\mathrm{S}^5-\frac{165}{4}\,\mathrm{S}^3+\frac{75}{8}\,\mathrm{S}\right)+\qquad\right\},$$

and

$$-\frac{\mathrm{S}}{r}\,\frac{d\mathrm{R}}{d\mathrm{S}}=m'\left\{-\frac{r}{r'^3}(3\,\mathrm{S}^2)-\frac{r^2}{r'^4}\left(\frac{15}{2}\,\mathrm{S}^3-\frac{3}{2}\,\mathrm{S}\right)-\frac{r^3}{r'^5}\left(\frac{35}{2}\,\mathrm{S}^4-\frac{15}{2}\,\mathrm{S}^2\right)\right.$$
$$\left.+\frac{r^4}{r'^6}\left(\frac{315}{8}\,\mathrm{S}^5-\frac{105}{4}\,\mathrm{S}^3+\frac{15}{8}\,\mathrm{S}\right)-\qquad\right\}$$

Employing these values, (10) reduces to

$$\frac{d\mathrm{R}}{d\psi}=-m'\sin\lambda\left\{\frac{r}{r'^3}+\frac{r^2}{r'^4}\,3\mathrm{S}-\frac{r^3}{r'^5}\left(-\frac{15}{2}\,\mathrm{S}^2+\frac{3}{2}\right)-\frac{r^4}{r'^6}\left(-\frac{35}{2}\,\mathrm{S}^3+\frac{15}{2}\,\mathrm{S}\right)+\qquad\right\}\qquad(11)$$

Replacing S by its value (5), and

$$\frac{d\mathrm{R}}{d\psi}=-m'\sin\lambda\left\{\frac{r}{r'^3}+\frac{r^2}{r'^4}\,3\left[\cos\lambda\cos(v-v')\right]\right.$$
$$+\frac{r^3}{r'^5}\,3\left[-\frac{1}{2}+\frac{5}{4}\cos^2\lambda\left(1+\cos 2\,(v-v')\right)\right]\qquad(12)$$
$$+\frac{r^4}{r'^5}\,3\left[\left(-\frac{5}{2}\cos\lambda+\frac{35}{8}\cos^3\lambda\right)\cos(v-v')+\frac{5}{4}\cos^3\lambda\cos 3\,(v-v')\right]$$
$$\left.+\qquad\right\}$$

This expression admits of being easily computed. Dividing by sin λ or $\frac{\psi}{r}$, the function becomes

$$\frac{r}{\psi}\,\frac{d\mathrm{R}}{d\psi}=-m'\left\{\frac{r}{r'^3}+\frac{r^2}{r'^4}\,3\cos\lambda\cos(v-v')+\qquad\right\},\qquad(13)$$

or a function of very similar form to R, from which it can be derived.

From these expressions for the function R and its differentials, the right hand side of the equation (A) is to be developed in explicit functions of t, so as to render possible the integration of the equations This will be effected in the following sections

§ 4

Suppose

$$r = r_0 + \delta r, \qquad v = v_0 + \delta v, \qquad \psi = \psi_0 + \delta\psi, \tag{1}$$

and let r_0, v_0, ψ_0 represent the values of r, v, ψ in the undisturbed motion of the Moon, so that δr, δv, $\delta\psi$ are the additional terms which represent the lunar perturbations. Let R° be the value of the disturbing function when the variables r, v, ψ have their undisturbed values r_0, v_0, ψ_0, and let δR be the additional term which arises from substituting in R for r_0, v_0, ψ_0 their complete values $r_0+\delta r$, $v_0+\delta v$, $\psi_0+\delta\psi$.

Then

$$R = R^{\circ} + \delta R$$

Expanding in powers of δr, δv, $\delta\psi$ in the usual manner, and

$$\begin{aligned}
R = R_0 + &\left\{\frac{dR^{\circ}}{dr_0}\delta r + \frac{dR^{\circ}}{dv_0}\delta v + \frac{dR^{\circ}}{d\psi_0}\delta\psi\right\} \\
+ \frac{1}{2}&\left\{\frac{d^2R^{\circ}}{dr_0^2}(\delta r)^2 + 2\frac{d^2R^{\circ}}{dr_0 dv_0}\delta r\,\delta v + \frac{d^2R^{\circ}}{dv_0^2}(\delta v)^2 + 2\frac{d^2R^{\circ}}{dr_0 d\psi_0}\delta r\,\delta\psi + 2\frac{d^2R^{\circ}}{dv_0 d\psi_0}\delta v\,\delta\psi + \frac{d^2R^{\circ}}{d\psi_0^2}(\delta\psi)^2\right\} \\
+ \frac{1}{6}&\left\{\frac{d^3R^{\circ}}{dr_0^3}(\delta r)^3 + 3\frac{d^3R^{\circ}}{dr_0^2 dv_0}(\delta r)^2\delta v + 3\frac{d^3R^{\circ}}{dr_0 dv_0^2}\delta r(\delta v)^2 + \frac{d^3R^{\circ}}{dv_0^3}(\delta v)^3\right. \\
&\quad + 3\frac{d^3R^{\circ}}{dr_0^2 d\psi_0}(\delta r)^2\delta\psi + 3\frac{d^3R^{\circ}}{d\psi_0 dv_0^2}\delta\psi(\delta v)^2 + 6\frac{d^3R}{dr_0 d\psi_0 dv_0}\delta r\,\delta\psi\,\delta v \\
&\quad \left. + 3\frac{d^3R^{\circ}}{dr_0 d\psi_0^2}\delta r(\delta\psi)^2 + 3\frac{d^3R^{\circ}}{dv_0 d\psi_0^2}\delta v(\delta\psi)^2 + \frac{d^3R}{d\psi_0^3}(\delta\psi)^3\right\} \\
+ \frac{1}{24}&\left\{ \qquad \qquad \qquad \right\} + \quad .
\end{aligned} \tag{2}$$

Expressing δr in terms of $\delta\,\frac{1}{r}$, from the equation

$$\left(\frac{\delta r}{r_0}\right) = \left\{1 + \left(\delta\,\frac{1}{r}\right)r_0\right\}^{-1} - 1 = \left\{-r_0\,\delta\,\frac{1}{r} + r_0^2\left(\delta\,\frac{1}{r}\right)^2 - r_0^3\left(\delta\,\frac{1}{r}\right)^3 + \qquad \right\}, \tag{3}$$

from this value

$$\left(\frac{\delta r}{r_0}\right)^2 = \left\{r_0^2\left[\delta\,\frac{1}{r}\right]^2 - 2r_0^3\left[\delta\,\frac{1}{r}\right]^3 + \qquad \right\},$$

$$\left(\frac{\delta r}{r_0}\right)^3 = \left\{ \qquad \qquad - r_0^3\left[\delta\,\frac{1}{r}\right]^3 + \qquad \right\}$$

For the purpose of forming the various differential coefficients of R^o, suppose that $R^o_{k,j}$ represents the portion of R^o which involves the kth power of r and the function $\cos j\,(v-v')$ Then

$$\left.\begin{aligned}
R^o_{2,0} &= m'\left\{\frac{r_o^2}{r_o'^3}\left[-\frac{1}{2}+\frac{3}{4}\cos^2\lambda_o\right]\right\},\\
R^o_{2,2} &= m'\left\{\frac{r_o^2}{r_o'^3}\left[\frac{3}{4}\cos^2\lambda_o\cos 2\,(v_o-v_o')\right]\right\},\\
R^o_{3,1} &= m'\left\{\frac{r_o^3}{r_o'^4}\left[\left(-\frac{3}{2}\cos\lambda_o+\frac{15}{8}\cos^3\lambda_o\right)\cos\,(v_o-v_o')\right]\right\},\\
R^o_{3,3} &= m'\left\{\frac{r_o^3}{r_o'^4}\left[\frac{5}{8}\cos^3\lambda_o\cos 3\,(v_o-v_o')\right]\right\},\\
R^o_{4,0} &= m'\left\{\frac{r_o^4}{r_o'^5}\left[\frac{3}{8}-\frac{15}{8}\cos^2\lambda_o+\frac{105}{64}\cos^4\lambda_o\right]\right\},\\
R^o_{4,2} &= m'\left\{\frac{r_o^4}{r_o'^5}\left[\left(-\frac{15}{8}\cos^2\lambda_o+\frac{35}{16}\cos^4\lambda_o\right)\cos 2\,(v_o-v_o')\right]\right\},\\
R^o_{4,4} &= m'\left\{\frac{r_o^4}{r_o'^5}\left[\frac{35}{64}\cos^4\lambda_o\cos 4\,(v_o-v_o')\right]\right\},\\
R^o_{5,1} &= m'\left\{\frac{r_o^5}{r_o'^6}\left[\left(\frac{15}{8}\cos\lambda_o-\frac{105}{16}\cos^3\lambda_o+\frac{315}{64}\cos^5\lambda_o\right)\cos\,(v_o-v_o')\right]\right\},\\
R^o_{5,3} &= m'\left\{\frac{r_o^5}{r_o'^6}\left[\left(-\frac{35}{16}\cos^3\lambda_o+\frac{315}{128}\cos^5\lambda\right)\cos 3\,(v_o-v_o')\right]\right\},\\
R^o_{5,5} &= m'\left\{\frac{r_o^5}{r_o'^6}\left[\frac{63}{128}\cos^5\lambda\cos 5\,(v_o-v_o')\right]\right\},
\end{aligned}\right\}\quad\text{(B)}$$

and

$$R^o = R^o_{2,0}+R^o_{2,2}+R^o_{3,1}+R^o_{3,3}+R^o_{4,0}+R^o_{4,2}+R^o_{4,4}+R^o_{5,1}+R^o_{5,3}+R^o_{5,5}+\cdots \quad = \Sigma R^o_{k,j}.$$

Differentiating with respect to r_o any of the above functions, and

$$r_o\frac{dR^o_{k,j}}{dr_o} = k\,R^o_{k,j},\qquad r_o^2\frac{d^2R^o_{k,j}}{dr_o^2} = k\,(k-1)\,R^o_{k,j},\qquad r_o^n\frac{d^nR^o_{k,j}}{dr_o^n} = \{k\,(k-1)\,\ldots\,(k+1-n)\}\,R^o_{k,j}$$

Therefore

$$r_o^n\frac{d^nR^o}{dr_o^n} = \Sigma\{(k)\,(k-1)\,(k-2)\ldots\,(k+1-n)\}\,R^o_{k,j}. \tag{6}$$

Similarly differentiating with respect to r_o',

$$r_o' \frac{dR^o_{\lambda,j}}{dr_o'} = -(\lambda+1)\, R^o_{\lambda,j}, \qquad\qquad r_o'^2 \frac{d^2R^o_{\lambda,j}}{dr_o'^2} = [-(\lambda+1)]\,[-(\lambda+2)]\, R^o_{\lambda,j},$$

$$r_o'^n \frac{d^nR^o_{\lambda,j}}{dr_o'^n} = (-1)^n\{(\lambda+1)\,(\lambda+2)\,. \quad (\lambda+n)\}R^o_{\lambda,j},$$

whence

$$r_o'^n \frac{d^nR^o}{dr_o'^n} = (-1)^n\Sigma\{(\lambda+1)\,(\lambda+2)\,(\lambda+3) \qquad (\lambda+n)\}R^o_{\lambda}, \tag{7}$$

Suppose the function R^o to be developed in a series of cosines, the argument of any term being a function of the four variables θ, α, β, μ, and the coefficient being denoted by R^o_a Then the function R^o may be written

$$[R^o]_{\cos} = \Sigma\ R^o_a \cos\phi\ (\theta,\ \alpha,\ \beta,\ \mu)\,, \tag{8}$$

and supposing the cosines changed into sines, but no other alteration made, the new function may be written

$$[R^o]_{\sin} = \Sigma\ R^o_a \sin\phi\ (\theta,\ \alpha,\ \beta,\ \mu) \tag{9}$$

Let the function R^o be developed in such a manner that all the terms depending on the factor $j\ (v_o-v_o')$ shall appear with arguments involving $j\theta$, and that this factor shall not arise in any other manner Then

$$R^o_{\lambda,j} = \Sigma\,(R^o_{\lambda,j})_a \cos\phi\ (j\theta,\ \alpha,\ \beta,\ \mu), \tag{10}$$

and assuming this condition to be strictly fulfilled,

$$\frac{dR^o_{\lambda,j}}{dv_o} = \frac{dR^o_{\lambda,j}}{d\theta} = -j\,\Sigma\ (R^o_{\lambda,j})_a \sin\phi\ (j\theta,\ \alpha,\ \beta,\ \mu) = -j\,[R^o_{\lambda,j}]_{\sin},$$

$$\frac{d^2R^o_{\lambda,j}}{dv_o^2} = \frac{d^2R^o_{\lambda,j}}{d\theta^2} = -j^2\Sigma\ (R^o_{\lambda,j})_a \cos\phi\ (j\theta,\ \alpha,\ \beta,\ \mu) = -j^2\,[R^o_{\lambda,j}]_{\cos},$$

whence

$$\frac{d^{2n}R^o}{dv_o^{2n}} = (-1)^n\ \Sigma\ j^{2n}\ R^o_{\lambda,j}, \tag{11}$$

$$\frac{d^{2n+1}R^o}{dv_o^{2n+1}} = (-1)^{n+1}\ \Sigma\ j^{2n+1}\ [R^o_{\lambda,j}]_{\sin}, \tag{12}$$

the summation extending to all values of j which are contained in R^o In a similar manner it can be shown that, as v_o and v_o' always and only enter into R^o in the form (v_o-v_o'),

$$\frac{d\mathrm{R}^o_{j,}}{dv_o'} = -\frac{d\mathrm{R}^o_{\lambda,}}{d\theta},$$

and

$$\frac{d^{2n}\mathrm{R}^o}{dv_o'^{2n}} = (-1)^{n+1}\, \Sigma j^{2n}\, \mathrm{R}^o_{\lambda j}, \tag{13}$$

$$\frac{d^{2n+1}\mathrm{R}^o}{dv_o'^{2n+1}} = (-1)^{n+2}\, \Sigma j^{2n+1}\, [\mathrm{R}^o_{\lambda,}]_{\sin} \tag{14}$$

R is the same function of the disturbed coordinates r, v, ψ, as R^o is of the undisturbed coordinates r_o, v_o, ψ_o, therefore the differentials of R with respect to r, v, ψ will be the same functions of these disturbed coordinates as the differentials of R^o, with respect to r_o, v_o, ψ_o will be of the undisturbed coordinates The results which have been found will apply in both instances

The differentials of R^o with respect to ψ_o are more conveniently obtained from $\frac{d\mathrm{R}}{d\psi}$, a function whose value has been already ascertained Let

$$\frac{d\mathrm{R}}{d\psi} = \psi \mathrm{Z}, \tag{15}$$

where Z is a function of r and S of the same form as R, or, by equation 11, § 3,

$$\mathrm{Z} = -m' \frac{1}{r'^3}\left\{1 + \frac{r}{r'}\, 3\mathrm{S} + \frac{r^2}{r'^2}\left(\frac{15}{2}\,\mathrm{S}^2 - \frac{3}{2}\right) + \cdot \qquad \right\}$$

From the above

$$\frac{d^2\mathrm{R}}{d\psi^2} = \mathrm{Z} + \psi\,\frac{d\mathrm{Z}}{d\psi} = \mathrm{Z} + \Delta\mathrm{Z} \tag{16}$$

It has been already shown that if Z be a function of r and S, then

$$\frac{d\mathrm{Z}}{d\psi} = \frac{1}{\psi}\,\Delta\mathrm{Z} = \frac{\psi}{r}\left\{\frac{d\mathrm{Z}}{dr} - \frac{\mathrm{S}}{r}\,\frac{d\mathrm{Z}}{d\mathrm{S}}\right\}$$

Substituting for $\frac{d\mathrm{Z}}{dr}$ and $\frac{d\mathrm{Z}}{d\mathrm{S}}$ their values derived from the value of Z given above, and

$$\psi\,\frac{d\mathrm{Z}}{d\psi} = \Delta\mathrm{Z} = -m'\,\frac{1}{r'^3}\left\{\frac{r^2}{r'^2} + \frac{r^3}{r'^3}\,5\mathrm{S} + \qquad \right\} 3\,\frac{\psi^2}{r^2} \tag{17}$$

Both $\frac{\psi^2}{r^2}$, or $\sin^2\lambda$, and $\frac{r^2}{r'^2}$ being very small quantities, it is obvious that their product, or $\Delta\mathrm{Z}$, must be very much smaller than Z It will subsequently be shown that $\Delta\mathrm{Z}$ is at least six orders smaller than Z Deferring to a future period the consideration of ΔZ, it may be assumed that

$$\frac{d^2R}{d\psi^2}=Z \tag{18}$$

Again, differentiating this last equation,

$$\frac{d^3R}{d\psi^3}=\frac{dZ}{d\psi}=\frac{1}{\psi}\,\Delta Z. \tag{19}$$

It has been just shown that ΔZ is extremely small, so that it can be neglected for the present, and thus the last equation may be written

$$\frac{d^3R}{d\psi^3}=0 \tag{20}$$

Equations 15, 18, 20 will hold true of the differentials of R^o with respect to ψ_o, if Z be changed into Z^o, for the reason stated in the preceding page

It remains to obtain the differentials of Z and ψZ with regard to r and θ Putting in the value for Z the proper equivalent for S and treating Z^o in the same manner as R^o, then

$$Z^o=Z^o_{00}+Z^o_{11}+Z^o_{20}+Z^o_{22}+\qquad+Z^o_{kj}=\Sigma Z^o_{kj}, \tag{21}$$

where

$$\left.\begin{aligned}
Z^o_{00}&=-m'\,\frac{1}{r_o'^3},\\
Z^o_{11}&=-m'\,\frac{r_o}{r_o'^4}\{3\cos\lambda_o\cos(v_o-v_o')\},\\
Z^o_{20}&=-m'\,\frac{r_o^2}{r_o'^5}\left\{\frac{3}{2}-\frac{15}{4}\cos^2\lambda_o\right\},\\
Z^o_{22}&=-m'\,\frac{r_o^2}{r_o'^5}\left\{\frac{15}{4}\cos^2\lambda_o\cos 2(v_o-v_o')\right\}
\end{aligned}\right\} \tag{C}$$

Similarly, putting for ψ_o its value $r_o \sin\lambda_o$,

$$\frac{dR^o}{d\psi_o}=\psi_o Z^o=\sin\lambda_o\,\Sigma Z^o_{(k+1)j},$$

In this manner, by the same process as the differentials of R^o were obtained, it can be shown that

$$\frac{d^{2n+1}R^o}{dv^{2n}\,d\psi}=\sin\lambda_o\,(-1)^n\,\Sigma\, j^{2n}\,Z^o_{(k+1)j}, \tag{22}$$

$$\frac{d^{2n+2}R^o}{dv^{2n+1}\,d\psi}=\sin\lambda_o\,(-1)^{n+1}\,\Sigma\, j^{2n+1}\,[Z^o_{(k+1)j}]_{\sin}, \tag{23}$$

$$r_o^{n+1}\,\frac{d^{n+1}R^o}{dr^{n+1}\,d\psi}=\sin\lambda_o\,\Sigma\{(k+1)\,(k)\,(k-1)\quad.(k+1-n)\}Z^o_{(k+1} \tag{24}$$

and

$$\frac{d^{2n+2}\,\mathrm{R}^o}{d\iota_o^{\,2n}\,d\psi_o^{\,2}} = (-1)^n\,\Sigma j^{2n}\,\mathrm{Z}^o_{l,j}\,, \tag{25}$$

$$\frac{d^{2n+3}\,\mathrm{R}^o}{dv_o^{\,2n+1}\,d\psi_o^{\,2}} = (-1)^{n+1}\,\Sigma j^{2n+1}\,[\mathrm{Z}^o_{l,j}]_{\sin}\,, \tag{26}$$

$$r_o^{n+1}\,\frac{d^{n+3}\,\mathrm{R}^o}{dr_o^{\,n+1}\,d\psi_o^{\,2}} = \Sigma\{l\;(l-1)\;(l-2)\qquad(l-n)\}\,\mathrm{Z}^o_{l,j}\,, \tag{27}$$

finally, all the differentials of $\frac{d^3\mathrm{R}^o}{d\psi_o^3}$ with respect to r_o and v_o may be put equal to zero

Substituting these values of the differentials of R^o with respect to r, ι, and ψ in the value of R, it becomes

$$\begin{aligned}
\mathrm{R} = \Sigma\mathrm{R}^o_{l,j} &+ \{\Sigma\, l\;\mathrm{R}^o_{l,j}\}\left(\frac{\partial r}{r_o}\right) \qquad + \{\Sigma\, l\;(l-1)\;\mathrm{R}^o_{l,j}\}\frac{1}{2}\left(\frac{\partial r}{r_o}\right)^2 \qquad + \{\Sigma\, l\;(l-1)\;(l-2)\;\mathrm{R}^o_{l,j}\}\frac{1}{6}\left(\frac{\partial r}{r_o}\right)^3 \\
&- \{\Sigma\, j\,[\mathrm{R}^o_{l,j}]_{\sin}\}(\partial\iota) \qquad - \{\Sigma\, j^2\,[\mathrm{R}^o_{l,j}]_{\cos}\}\frac{1}{2}(\partial v)^2 \qquad + \{\Sigma\, j^3\,[\mathrm{R}^o_{l,j}]_{\sin}\}\frac{1}{6}(\partial\iota)^3 \\
&- \{\Sigma\, l\; j\,[\mathrm{R}^o_{l,j}]_{\sin}\}\left(\frac{\partial r}{r_o}\right)(\partial\iota) - \{\Sigma\, l\; j^2\,[\mathrm{R}^o_{l,j}]_{\cos}\}\frac{1}{2}\left(\frac{\partial r}{r_o}\right)(\partial\iota)^2 \qquad - \{\Sigma l\;(l-1)\;[\mathrm{R}^o_{l,j}]_{\sin}\}\frac{1}{2}\left(\frac{\partial r}{r_o}\right)^2(\partial v) \\
&+ \{\Sigma\;\mathrm{Z}^o_{(l+1),j}\}\sin\lambda\;(\partial\psi) \qquad + \{\Sigma\;(l+1)\;\mathrm{Z}^o_{(l+1),j}\}\sin\lambda\left(\frac{\partial r}{r_o}\right)(\partial\psi) \qquad - \{\Sigma j\;[\mathrm{Z}^o_{(l+1),j}]_{\sin}\}\sin\lambda\;(\partial\iota)\;(\partial\psi) \\
&\qquad + \{\Sigma\;(l+1)\;l\;\mathrm{Z}^o_{(l+1),j}\}\sin\lambda\;\frac{1}{2}\left(\frac{\partial r}{r_o}\right)^2(\partial\psi) - \{\Sigma j^2\,[\mathrm{Z}^o_{(l+1),j}]_{\cos}\}\sin\lambda\;\frac{1}{2}\;(\partial v)^2\;(\partial\psi) \\
&\qquad\qquad - \{\Sigma\;(l+1)\;j\;[\mathrm{Z}^o_{(l+1),j}]_{\sin}\}\sin\lambda\left(\frac{\partial r}{r_o}\right)(\partial v)\;(\partial\psi) \\
&+ \{\Sigma\mathrm{Z}^o_{l,j}\}\frac{1}{2}\;(\partial\psi)^2 \qquad + \{\Sigma l\;\;\mathrm{Z}^o_{l,j}\}\frac{1}{2}\left(\frac{\partial r}{r_o}\right)(\partial\psi)^2 \qquad - \{\Sigma j\;[\mathrm{Z}^o_{l,j}]_{\sin}\}\frac{1}{2}\;(\partial v)\;(\partial\psi)^2 \\
&\qquad +
\end{aligned} \tag{28}$$

Rearranging the different terms, and

$$
\begin{aligned}
R = \; & \Sigma\{1+\lambda\left[\frac{\partial r}{r_o}\right]+\frac{1}{2}\lambda\,[\lambda-1]\left[\frac{\partial r}{r_o}\right]^2+\frac{1}{6}\lambda\,[\lambda-1]\,[\lambda-2]\left[\frac{\partial r}{r_o}\right]^3+ \qquad -\frac{1}{2}j^2\,(1+\lambda\left[\frac{\partial r}{r_o}\right]+ \qquad)\,[\partial v]^2+ \qquad \}\,[R^o_{\lambda,j}]_{\cos} \\
& +\Sigma\{-j\,(1+\lambda\left[\frac{\partial r}{r_o}\right]+\frac{1}{2}\lambda\,[\lambda-1]\left[\frac{\partial r}{r_o}\right]^2+ \qquad)\,[\partial v]+ \qquad +\frac{1}{6}j^3\,(1+ \qquad)\,[\partial v]^3+ \qquad \}\,[R^o_{\lambda,j}]_{\sin} \\
& +\sin\lambda_o\,[\partial\psi]\,\{\Sigma\{1+[\lambda+1]\left[\frac{\partial r}{r_o}\right]+[\lambda+1]\,\lambda\left[\frac{\partial r}{r_o}\right]^2+ \qquad -\frac{1}{2}j^2\,(1+ \qquad)\,[\partial v]^2+ \qquad \}\,[Z^o_{(\lambda+1)j}]_{\cos} \\
& \qquad\qquad +\Sigma\{-j\,(1+[\lambda+1]\left[\frac{\partial r}{r_o}\right]+ \qquad)\,[\partial v]+ \qquad \}\,[Z^o_{(\lambda+1)j}]_{\sin}\} \\
& +\frac{1}{2}[\partial\psi]^2\{\Sigma\{1+\lambda\left[\frac{\partial r}{r_o}\right]+ \qquad \}\,[Z^o_{\lambda,j}]_{\cos}+\Sigma\{-j\,(1+ \qquad)\,[\partial v]+ \qquad \}\,[Z^o_{\lambda,j}]_{\sin}\} \\
& +
\end{aligned}
$$

In the above expression for $\left[\frac{\partial r}{r_o}\right]$ and its powers, substitute their values in terms of $\left[\partial\,\frac{1}{r}\right]$,

$$
\begin{aligned}
R = \; & \Sigma\{1-\lambda\left[r_o\partial\,\frac{1}{r}\right]+(\lambda+\frac{1}{2}\lambda\,[\lambda-1])\left[r_o\partial\,\frac{1}{r}\right]^2-(\lambda+\lambda\,[\lambda-1]+\frac{1}{6}\lambda\,[\lambda-1]\,[\lambda-2])\left[r_o\partial\,\frac{1}{r}\right]^3+ \\
& \quad -\frac{1}{2}j^2\,(1-\lambda\left[r_o\partial\,\frac{1}{r}\right]+ \qquad)\,[\partial v]^2+ \qquad \}\,[R^o_{\lambda,j}] \\
& +\Sigma\{-j\,(1-\lambda\left[r_o\partial\,\frac{1}{r}\right]+(\lambda+\frac{1}{2}\lambda\,[\lambda-1])\left[r_o\partial\,\frac{1}{r}\right]^2- \qquad)\,[\partial v] \\
& \quad +\frac{1}{6}j^3\,(1- \qquad)\,[\partial v]^3+ \qquad \}\,[R^o_{\lambda,j}]_{\sin} \qquad\qquad (D) \\
& +\sin\lambda_o\,[\partial\psi]\,\{\Sigma\{1-[\lambda+1]\left[r_o\partial\,\frac{1}{r}\right]+([\lambda+1]+\frac{1}{2}\lambda\,[\lambda+1])\left[r_o\partial\,\frac{1}{r}\right]^2- \qquad -\frac{1}{2}j^2\,(1- \qquad)\,[\partial v]^2+ \qquad \}\,[Z^o_{(\lambda+1)j}]_{\cos} \\
& \qquad\qquad +\Sigma\{-j\,(1-[\lambda+1]\left[r_o\partial\,\frac{1}{r}\right]+ \qquad)\,[\partial v]+ \qquad \}\,[Z^o_{(\lambda+1)j}]_{\sin}\} \\
& +\frac{1}{2}[\partial\psi]^2\{\Sigma\{1-\lambda\left[r_o\partial\,\frac{1}{r}\right]+ \qquad \}\,[Z^o_{\lambda,j}]_{\cos}+\Sigma\{-j\,(1- \qquad)\,[\partial v]+ \qquad \}\,[Z^o_{\lambda,j}]_{\sin}\} \\
& +
\end{aligned}
$$

The above is the complete expression for R in terms of R^o_{ij}, Z^o_{ij}, and the three variations, $\delta\frac{1}{r}$, δv, and $\delta\psi$ It is symmetrical, and could be at once extended to a still higher power of the variations without any trouble As far as the fourth power of $\delta\frac{1}{r}$, δv, $\delta\psi$ it would be complete if thus extended, if pushed to the fifth power the terms of the form of ΔZ_o which have been omitted would have to be supplied

§ 5.

Resuming the differential equation to the radius vector,

$$\frac{1}{2}\frac{d^2(r_o)^2}{dt^2}-\frac{1}{r}+c=r\frac{dR}{dr}+2\int\left(\frac{dR}{dt}\right)dt=Q, \tag{1}$$

and putting for r its value $r_o+\delta r$, expand r^2 in powers of $\delta\frac{1}{r}$, when

$$r^2=\left\{\frac{1}{r_o}+\delta\frac{1}{r}\right\}^{-2}=r_o^2-2r_o^3\left[\delta\frac{1}{r}\right]+3r_o^4\left[\delta\frac{1}{r}\right]^2-4r_o^5\left[\delta\frac{1}{r}\right]^3+5r_o^6\left[\delta\frac{1}{r}\right]^4-$$

For convenience let

$$\Delta\ (r)=(1-r_o^3)\left[\delta\frac{1}{r}\right]+\frac{3}{2}r_o^4\left[\delta\frac{1}{r}\right]^2-2r_o^5\left[\delta\frac{1}{r}\right]^3+\frac{5}{2}r_o^6\left[\delta\frac{1}{r}\right]^4-\quad, \tag{2}$$

$$\Delta''(r)=\frac{d^2\Delta(r)}{dt^2}, \tag{3}$$

$$F(r_o)=\frac{1}{2}\frac{d^2(r_o^2)}{dt^2}-\frac{1}{r_o}+C \tag{4}$$

Then substituting the above value of r^2 in the differential equation, and making use of the specified abbreviations, it becomes

$$\begin{aligned}\frac{d^2\left(\delta\frac{1}{r}\right)}{dt^2}+\delta\frac{1}{r}&=F(r_o)+\Delta''(r)-r\frac{dR}{dr}-2\int\left(\frac{dR}{dt}\right)dt\\&=F(r_o)+\Delta''(r)-Q\end{aligned}$$

The function Q has next to be expressed in terms of R^o_{ij} and similar functions, and the variations $\delta\frac{1}{r}$, δv, $\delta\psi$, in the same manner as R has been already developed

As R and R^o are identical functions of the disturbed and undisturbed coordinates respectively, their differentials with respect to these coordinates will possess the same identity of form Consequently, by § 4, Eq 6,

$$r\frac{dR}{dr} = \Sigma\, h\, R_{h,j},$$

and $R_{h,j}$, which is assumed to be the same function of the disturbed coordinates as $R^{\circ}_{h,j}$ is of the undisturbed coordinates, has been already developed, it being a particular value of Eq D Only $\int\left(\frac{dR}{dt}\right)dt$ therefore requires consideration The partial differential $\left(\frac{dR}{dt}\right)$ has been defined as the differential of R in so far as the variable t is introduced by the lunar coordinates Therefore (§ 2, Eq 5)

$$\left(\frac{dR}{dt}\right) = \frac{dR}{dx}\frac{dx}{dt} + \frac{dR}{dy}\frac{dy}{dt} + \frac{dR}{dz}\frac{dz}{dt}, \qquad (6)$$

whereas the complete differential of R with respect to t is

$$\frac{dR}{dt} = \frac{dR}{dx}\frac{dx}{dt} + \frac{dR}{dy}\frac{dy}{dt} + \frac{dR}{dz}\frac{dz}{dt} + \frac{dR}{dx'}\frac{dx'}{dt} + \frac{dR}{dy'}\frac{dy'}{dt} + \frac{dR}{dz'}\frac{dz'}{dt} \qquad (7)$$

Consequently, putting

$$\left(\frac{dR}{dt}\right)' = \frac{dR}{dx'}\frac{dx'}{dt} + \frac{dR}{dy'}\frac{dy'}{dt} + \frac{dR}{dz'}\frac{dz'}{dt}, \qquad (8)$$

then

$$\left(\frac{dR}{dt}\right) = \frac{dR}{dt} - \left(\frac{dR}{dt}\right)',$$

whence integrating,

$$\int\left(\frac{dR}{dt}\right)dt = R - \int\left(\frac{dR}{dt}\right)'dt.$$

As z' is supposed to be zero, equation (8) may be written

$$\left(\frac{dR}{dt}\right)' = r'\frac{dR}{dr'}\,\frac{1}{r'}\,\frac{dr'}{dt} + \frac{dR}{dv'}\,\frac{dv'}{dt}. \qquad (9)$$

From Equations 7, 13, and 14 of the preceding section may be derived the expressions

$$r'\frac{dR}{dr'} = -\Sigma\,(h+1)\,R_{h,j},$$

$$\frac{dR}{dv'} = +\Sigma j\,[R_{h,j}]_{\sin}$$

Substituting these values,

$$\left(\frac{d\mathrm{R}}{dt}\right)' = -\Sigma\,(i+1)\,\mathrm{R}_{i,j}\left(\frac{1}{r'}\,\frac{dr'}{dt}\right) + \Sigma j\,[\mathrm{R}_{i,j}]_{\sin}\left(\frac{dv'}{dt}\right) \qquad (10)$$

Suppose

$$\frac{1}{r'}\,\frac{dr'}{dt} = m\Sigma c'\sin\gamma, \qquad \frac{dv'}{dt} = m + m\Sigma c''\cos\gamma\,, \qquad (11)$$

then, substituting all these values,

$$\int\left(\frac{d\mathrm{R}}{dt}\right)dt = \mathrm{R} + m\int\{\Sigma\,(i+1)\,[\mathrm{R}_{i,j}]_{\cos}\,[\Sigma c'\sin\gamma] - \Sigma j\,[\mathrm{R}_{i,j}]_{\sin}\,[1+\Sigma c''\cos\gamma]\}\,dt. \qquad (12)$$

Therefore

$$\mathrm{Q} = \Sigma\,(i+2)\,\mathrm{R}_{i,j} - 2m\int\{\Sigma j\,[\mathrm{R}_{i,j}]_{\sin} - \Sigma\,(i+1)\,[\mathrm{R}_{i,j}]_{\cos}\,[\Sigma c'\sin\gamma] + \Sigma j\,[\mathrm{R}_{i,j}]_{\sin}\,[\Sigma c''\cos\gamma]\}\,dt \qquad (13)$$

Substituting this value in (5) the differential equation to the radius vector is completely developed

The differential equation for ψ is

$$\frac{d^2\psi}{dt^2} + \frac{\psi}{r^3} = \frac{d\mathrm{R}}{d\psi} \qquad (14)$$

Writing in this $\psi_o + \delta\psi$ for ψ, and putting

$$\mathrm{F}\,(\psi_o) = -\frac{d^2\psi_o}{dt^2} - \psi_o, \qquad (15)$$

$$f\,(r) = 1 - \frac{1}{r_o^3}\left\{1 + 3\left(r_o\delta\,\frac{1}{r}\right) + 3\left(r_o\delta\,\frac{1}{r}\right)^2 + \left(r_o\delta\,\frac{1}{r}\right)^3\right\}, \qquad (16)$$

the above equation becomes

$$\frac{d^2\delta\psi}{dt^2} + \delta\psi = \mathrm{F}\,(\psi_o) + f\,(r)\,\{\psi_o + \delta\psi\} + \frac{d\mathrm{R}}{d\psi}, \qquad (17)$$

which is the form under which it will be employed.

Finally, the differential equation for the longitude of the Moon is

$$\frac{dv}{dt} = \frac{1}{r^2 - \psi^2}\left\{h + \int\frac{d\mathrm{R}}{dv}\,dt\right\}. \qquad (18)$$

As

$$\frac{1}{r^2} = \frac{1}{r_o^2}\left\{1 + 2\left(r_o\delta\,\frac{1}{r}\right) + \left(r_o\delta\,\frac{1}{r}\right)^2\right\},$$

$$\psi^2 = \psi_o^2 + 2\psi_o\delta\psi + (\delta\psi)^2,$$

the term without the brackets in (18) on being expanded becomes

$$\frac{1}{r^2-\psi^2}=\frac{1}{r_o^2}\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}\Big[1+\frac{1}{r_o^2}\{\psi_o^2+2\psi_o\delta\psi+(\delta\psi)^2\}\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}$$
$$-\frac{1}{r_o^4}\{\psi_o^2+2\psi_o\delta\psi+(\delta\psi)^2\}^2\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}^2$$
$$+\frac{1}{r_o^6}\{\psi_o^2+2\psi_o\delta\psi+(\delta\psi)^2\}^3\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}^3-\quad\Big] \tag{19}$$

Next, from the value already found (Eq 11, § 4)

$$\frac{dR}{dv}=-\Sigma j\,[R_{k,j}]_{\sin}$$

Substituting these values,

$$\frac{dv}{dt}=\frac{1}{r_o^2}\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}\Big[1+\frac{1}{r_o^2}\{\psi_o^2+2\psi_o\delta\psi+(\delta\psi)^2\}\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}$$
$$-\frac{1}{r_o^4}\{\psi_o^2+2\psi_o\delta\psi+(\delta\psi)^2\}^2\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}^2$$
$$+\frac{1}{r_o^6}\{\psi_o^2+2\psi_o\delta\psi+(\delta\psi)^2\}^3\left\{1+2\left(r_o\delta\frac{1}{r}\right)+\left(r_o\delta\frac{1}{r}\right)^2\right\}^3-\cdot\cdot\ \Big]\left\{h-\int\Sigma j\,[R^o_{k,j}]_{\sin}dt\right\} \tag{20}$$

§ 6.

The perturbations of the Moon's radius vector, or $\delta\frac{1}{r}$, will consist of a series of cosines of different arguments, and r_o being also a series of cosines, their product, $r_o\,\delta\frac{1}{r}$, and all its powers will consist of series of cosines Suppose therefore

$$\left[r_o\delta\frac{1}{r}\right]^l=A_l^l\cos\beta=\Sigma A_a^l\cos\phi\,(\theta\ \ \alpha\ \ \beta\ \ \mu), \tag{1}$$

the term $A_l^l\cos\beta$ being supposed to represent the general term, and which is supposed to successively represent every term in $[r_o\delta\frac{1}{r}]^l$. In the same manner let

$$[\delta v]^{l'}=A_v^{l'}\sin\beta=\Sigma B_a^{l'}\sin\phi\,(\theta\ \ \alpha.\beta\ \ \mu), \tag{2}$$

the perturbations of the Moon's longitude being represented by a series of sines, and $A''_{v}\sin\beta$ being the general term, and supposed to be made in succession equal to every term in the perturbations in longitude Lastly, in conformity with the same principle, let

$$[R^{o}_{k,j}]_{\cos} = R^{a}_{k,j}\cos\alpha = \Sigma_{k,j} R_{a}\cos\phi\,(\theta\ \alpha\ \beta\ \mu) \tag{3}$$

and

$$[R^{o}_{k,j}]_{\sin} = R^{a}_{k,j}\sin\alpha = \Sigma_{k,j} R_{a}\sin\phi\,(\theta\ \alpha\ \beta\ \mu), \tag{4}$$

the coefficients of the last two series being identical when their arguments are the same

It has been stated already that it has been found more convenient to consider the effects of the perturbations in latitude through the aid of a different function to that by which the effects which are independent of the perturbations in latitude are computed For the present therefore the perturbations will be considered to be zero

Then putting Q' for the value of Q under these conditions,

$$Q' = \Sigma[k+2][R_{k,j}]_{\cos} - 2m\int\Sigma\{j[R_{k,j}]_{\sin} - (k+1)[R_{k,j}]_{\cos}\ (\Sigma c'\sin\gamma) + j[R_{k,j}]_{\sin}\ (\Sigma c''\cos\gamma)\}\,dt \tag{5}$$

Next, write for convenience

$$\overset{+}{A}_{k,j} = \tfrac{1}{2}\{(1 - kA_{,} + (k + \tfrac{1}{2}k[k-1])A_{,}^{2} - (k + k[k-1] + \tfrac{1}{6}k[k-1][k-2])A_{,}^{3} + \cdot\ \ )$$

$$(1 + jA_{v} - \tfrac{1}{2}j^{2}A_{v}^{2} - \tfrac{1}{6}j^{3}A_{v}^{3} + \quad) - 1\}, \tag{6}$$

$$\overline{A}_{k,j} = \tfrac{1}{2}\{(1 - kA_{,} + (k + \tfrac{1}{2}k[k-1])A_{,}^{2} - (k + k[k-1] + \tfrac{1}{6}k[k-1][k-2])A_{,}^{3} + \quad)$$

$$(1 - jA_{v} - \tfrac{1}{2}j^{2}A_{v}^{2} + \tfrac{1}{6}j^{3}A_{v}^{3} + \quad) - 1\}, \tag{7}$$

and substitute in the value already found for $R_{k,j}$ (Eq. D) It becomes

$$\begin{aligned} R_{k,j} &= R^{a}_{k,j}\{\cos\alpha + ([\overline{A}_{k,j} + \overset{+}{A}_{k,j}]\cos\beta)\cos\alpha + ([\overline{A}_{k,j} - \overset{+}{A}_{k,j}]\sin\beta)\sin\alpha\} \\ &= R^{a}_{k,j}\{\cos\alpha + \overset{+}{A}_{k,j}\cos(\alpha+\beta) + \overline{A}_{k,j}\cos(\alpha-\beta)\} \end{aligned} \tag{8}$$

Substituting this expression in the value of Q' it becomes

$$
\begin{aligned}
Q' = \Sigma\,(\lambda+2)\,R^{\alpha}_{\lambda,j}\{\cos\alpha + \overset{+}{A}_{\lambda,j}\cos(\alpha+\beta) + \bar{A}_{\lambda,j}\cos(\alpha-\beta)\} \\
- m\int \Sigma R^{\alpha}_{\lambda,j}\{[2j\sin\alpha \quad - 2\,[\lambda+1]\,(\Sigma c'\sin\gamma)\cos\alpha \quad + 2j\,(\Sigma c''\cos\gamma)\sin\alpha \quad] \\
+ \overset{+}{A}_{\lambda,j}\,[2j\sin(\alpha+\beta) - 2\,[\lambda+1]\,(\Sigma c'\sin\gamma)\cos(\alpha+\beta) + 2j\,(\Sigma c''\cos\gamma)\sin(\alpha+\beta)\,] \qquad (9) \\
+ \bar{A}_{\lambda,j}\,[2j\sin(\alpha-\beta) - 2\,[\lambda+1]\,(\Sigma c'\sin\gamma)\cos(\alpha-\beta) + 2j\,(\Sigma c''\cos\gamma)\sin(\alpha-\beta)]\}\,dt
\end{aligned}
$$

In conformity with the principle already applied to the expressions for the perturbations, suppose that the sign of summation Σ is understood before c', c'', γ Then, effecting the multiplications,

$$
\begin{aligned}
Q' = \Sigma\,(\lambda+2)\,R^{\alpha}_{\lambda,j}\{\cos\alpha + \overset{+}{A}\cos(\alpha+\beta) + \bar{A}\cos(\alpha-\beta)\} \\
- m\int \Sigma R^{\alpha}_{\lambda,j}\{[2j\sin\alpha \quad - ([\lambda+1]\,c' - jc'')\sin(\alpha+\gamma) \quad + ([\lambda+1]\,c' + jc'')\sin(\alpha-\gamma) \quad] \qquad (10) \\
+ \overset{+}{A}_{\lambda,j}\,[2j\sin(\alpha+\beta) - ([\lambda+1]\,c' - jc'')\sin(\alpha+\beta+\gamma) + ([\lambda+1]\,c' + jc'')\sin(\alpha+\beta-\gamma)\,] \\
+ \bar{A}_{\lambda,j}\,[2j\sin(\alpha-\beta) - ([\lambda+1]\,c' - jc'')\sin(\alpha-\beta+\gamma) + ([\lambda+1]\,c' + jc'')\sin(\alpha-\beta-\gamma)]\}\,dt
\end{aligned}
$$

In effecting the integration, for convenience suppose the coefficients of t in the functions α, β, γ are α_1, β_1, γ_1 respectively, so that

$$
\int\sin(\alpha+\beta+\gamma) = -\frac{1}{\alpha_1+\beta_1+\gamma_1}\cos(\alpha+\beta+\gamma) \qquad (11)
$$

Then, by integrating and rearranging, Q′ becomes

$$
\begin{aligned}
Q' = \Sigma R^{a}_{h,j}\Big\{ & \Big\{\Big([h+2]+2j\,\frac{m}{a_1}\Big)\cos a \quad - m\,\frac{[h+1]\,c'-jc''}{a_1+\gamma_1}\cos(a+\gamma) \quad + m\,\frac{[h+1]\,c'+jc''}{a_1-\gamma_1}\cos(a-\gamma)\Big\} \\
& + \frac{1}{2}\Big\{\Big(1-hA_{,}+\Big(h+\frac{1}{2}h\,[h-1]\Big)A_{,}^{2}-\Big(h+h\,[h-1]+\frac{1}{6}[h]\,[h-1]\,[h-2]\Big)A_{,}^{3}+\quad\Big)\Big(1+jA_{,}-\frac{1}{2}j^{2}A_{,}^{2}-\frac{1}{6}j^{3}A_{,}^{3}+\quad\Big)-1\Big\} \\
& \Big\{\Big([h+2]+2j\,\frac{m}{a_1+\beta_1}\Big)\cos(a+\beta)-m\,\frac{(h+1)\,c'-jc''}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)+m\,\frac{[h+1]\,c'+jc''}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\Big\} \qquad (12) \\
& + \frac{1}{2}\Big\{\Big(1-hA_{,}+\Big(h+\frac{1}{2}h\,[h-1]\Big)A_{,}^{2}-\Big(h+h\,[h-1]+\frac{1}{6}[h]\,[h-1]\,[h-2]\Big)A_{,}^{3}+\quad\Big)\Big(1-jA_{,}-\frac{1}{2}j^{2}A_{,}^{2}+\frac{1}{6}j^{3}A_{,}^{3}+\quad\Big)-1\Big\} \\
& \Big\{\Big([h+2]+2j\,\frac{m}{a_1-\beta_1}\Big)\cos(a-\beta)-m\,\frac{(h+1)\,c'-jc''}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)+m\,\frac{[h+1]\,c'+jc''}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\Big\}\Big\}
\end{aligned}
$$

The above is the complete value of Q′ as far as the perturbations in radius vector and longitude are concerned.

Returning to the consideration of the terms depending on the perturbations in latitude, the form they take in Q can be readily derived from the above For in these new terms $Z^{a}_{(j+1)}$, and $Z^{a}_{h,j}$, which take the place of $R^{a}_{h,j}$, and sin λ (δψ) and ½ (δψ)², which, together with a function of the variations $\delta\frac{1}{r}$ and δt, take the place of $\overset{\pm}{A}$ in the value of Q′, are of the same form as the functions they replace The only effect, therefore, of these alterations will be to change the particular form of the coefficients and arguments which constitute Q′, but substituting for them others varying merely in being different letters representing analogous quantities It is merely necessary to make these formal changes in Q′ to convert it into the new terms that are required

Suppose then

$$Z^{o}_{(k+1)j} = Z^{a}_{(k+1)j} \cos \alpha', \tag{13}$$

$$Z^{o}_{kj} \quad = Z^{a}_{kj} \cos \alpha'', \tag{14}$$

and

$$\sin \lambda \, (\partial\psi) = A_z \cos \beta', \tag{15}$$

$$\frac{1}{2} (\partial\psi)^2 = A_z^2 \cos \beta'', \tag{16}$$

on the same principle of notation as before, these being supposed to represent the general terms Then, referring the general function to the single general argument in the same manner as before, it may be supposed that

$$\sin \lambda \, (\partial\psi) \; \{1 - [k+1] \left[r_0\partial \frac{1}{r}\right] + ([k+1] + \frac{1}{2} k \, [k+1]) \left[r_0\partial \frac{1}{r}\right]^2 - \quad - \frac{1}{2} r^2 \, [\partial v]^2 \quad \}$$
$$= \{A_z \, (1 + \bar{A}_{(k+1)j} + \overset{+}{A}_{(l+1)j}) \cos \beta' \}, \tag{17}$$

exactly as it has been assumed that

$$\{1 - (k) \quad \left[r_0\partial \frac{1}{r}\right] + (k \quad + \frac{1}{2} k \, [k-1]) \left[r_0\partial \frac{1}{r}\right]^2 - \quad - \frac{1}{2} r^2 \, [\partial v]^2 \quad \}$$
$$= \{ \quad (1 + \bar{A}_{lj} \quad + \overset{+}{A}_{kj} \quad) \cos \beta \}$$

Then, according to the method which is mentioned on the preceding page, let R^{a}_{kj}, α, β, $\overset{+}{A}_{lj}$, $\bar{A}_{kj}$ be replaced by $Z^{a}_{(k+1)j}$, α', β', $A_z \overset{+}{A}_{kj}$, and $A \, \bar{A}_{kj}$ respectively, Q′ will yield the additional terms in Q which depend on the first power of the perturbations in latitude, neglecting of course in Q′ the portion which is independent of the perturbation In the same manner, replacing in the last $Z^{a}_{(k+1)j}$, α', β', A_z by Z^{a}_{kj}, α'', β'', A_z^2, the second portion of Q depending on the second power of the perturbations in latitude will be obtained Make these changes and add together the different portions, and the complete value of Q will be

$$
\begin{aligned}
Q = \quad & \Sigma R^{a}_{l,j} \quad \Big\{ \Big\{ \Big([h+2] + 2j\frac{m}{a_1} \Big) \cos a \qquad - m\frac{[h+1]\,c' - jc''}{a_1+\gamma_1} \cos(a+\gamma) \qquad + m\frac{[h+1]\,c' + jc''}{a_1-\gamma_1} \cos(a-\gamma) \quad \Big| \\
& + \frac{1}{2}\{ \big(1 - hA_r + (h + \tfrac{1}{2} h\,[h-1])\,A_r^{2} - (h + h\,[h-1] + \tfrac{1}{6} h\,[h-1][h-2])\,A_{,}^{3} + \qquad \big) \big(1 + jA_v - \tfrac{1}{2} j^2 A_v^{2} - \tfrac{1}{6} j^3 A_v^{3} + \qquad \big) - 1 \} \\
& \quad \Big\{ \Big([k+2] + 2j\frac{m}{a_1+\beta_1} \Big) \cos(a+\beta) \qquad - m\frac{[h+1]\,c' - jc''}{a_1+\beta_1+\gamma_1} \cos(a+\beta+\gamma) \quad + m\frac{[h+1]\,c' - jc''}{a_1+\beta_1-\gamma_1} \cos(a+\beta-\gamma) \quad \Big\} \\
& + \frac{1}{2}\{ \big(1 - hA_{,} + (h + \tfrac{1}{2} h\,[h-1])\,A_{,}^{2} - (h + h\,[h-1] + \tfrac{1}{6} h\,[h-1][h-2])\,A_{,}^{3} + \qquad \big) \big(1 - jA_v - \tfrac{1}{2} j^2 A_v^{2} + \tfrac{1}{6} j^3 A_v^{3} + \qquad \big) - 1 \} \\
& \quad \Big\{ \Big([h+2] + 2j\frac{m}{a_1-\beta_1} \Big) \cos(a-\beta) \qquad - m\frac{[h+1]\,c' - jc''}{a-\beta+\gamma_1} \cos(a-\beta+\gamma) \quad + m\frac{[h+1]\,c' - jc''}{a_1-\beta_1-\gamma_1} \cos(a-\beta-\gamma) \quad \Big\} \Big\} \\
+ & \Sigma Z^{a}_{[h+1],j} \Big\{ \frac{1}{2}\{ A_z \big(1 - [h+1]\,A_{,} + ([h+1] + \tfrac{h}{2}[h+1])\,A_{,}^{2} - \qquad \big) \big(1 + jA_v - \tfrac{1}{2} j^2 A_v^{2} - \ \cdot \ \big) \} \qquad (18) \\
& \quad \Big\{ \Big([h+3] + 2j\frac{m}{a_1'+\beta_1'} \Big) \cos(a'+\beta') \quad - m\frac{[h+2]\,c' - jc''}{a_1'+\beta_1'+\gamma_1} \cos(a'+\beta'+\gamma) \quad + m\frac{[h+2]\,c' - jc''}{a_1'+\beta_1'-\gamma_1} \cos(a'+\beta'-\gamma) \quad \Big\} \\
& \quad + \frac{1}{2}\{ A_z \big(1 - [h+1]\,A_r + ([h+1] + \tfrac{1}{2} h\,[h+1])\,A_{,}^{2} - \qquad \big) \big(1 - jA_\iota - \tfrac{1}{2} j^2 A_v^{2} + \qquad \big) \} \\
& \quad \Big\{ \Big([h+3] + 2j\frac{m}{a_1'-\beta_1'} \Big) \cos(a'-\beta') \quad - m\frac{[h+2]\,c' - jc''}{a_1'-\beta_1'+\gamma_1} \cos(a'-\beta'+\gamma) \quad + m\frac{[h+2]\,c' - jc''}{a_1'-\beta_1'-\gamma_1} \cos(a'-\beta'-\gamma) \quad \Big\} \Big\} \\
+ & \Sigma Z^{a}_{l,j} \quad \Big\{ \frac{1}{2}\{ A_z^{2} \big(1 - hA_{,} + \qquad \big) \big(1 + jA_v - \cdot \qquad \big) \} \\
& \quad \Big\{ \Big([h+2] + 2j\frac{m}{a_1''+\beta_1''} \Big) \cos(a''+\beta'') - m\frac{[h+1]\,c' - jc''}{a_1''+\beta_1''+\gamma} \cos(a''+\beta''+\gamma) + m\frac{[h+1]\,c' - jc''}{a_1''+\beta_1''-\gamma} \cos(a''+\beta''-\gamma) \Big\} \\
& \quad + \frac{1}{2}\{ A_z^{2} \big(1 - hA_{,} + \qquad \big) \big(1 - jA_\iota - \qquad \big) \} \\
& \quad \Big\{ \Big([h+2] + 2j\frac{m}{a_1''-\beta_1'} \Big) \cos(a''-\beta'') - m\frac{[h+1]\,c' - jc''}{a_1''-\beta_1''+\gamma_1} \cos(a''-\beta''+\gamma) + m\frac{[h+1]\,c' - jc''}{a_1''-\beta_1''-\gamma} \cos(a''-\beta''-\gamma) \Big\} \Big\}
\end{aligned}
$$

The above is the complete value of Q, and forms the principal portion of the differential equation to the radius vector. Treating the function $\Delta(r)$ in the same manner (putting therein $r_o^2 = U^2 \cos \beta^o$) and substituting its value, with the above value of Q, the differential equation to the radius vector becomes

$$
\begin{aligned}
&\frac{d^2\delta\frac{1}{r}}{dt^2}+\delta\frac{1}{r}=\{1-(\beta^o{}_1)^2\}U^2\cos\beta^o+\{(\beta_1)^2\,U^2\,(A_{,}-\tfrac{3}{2}A_{,}^2+2A_{,}^3-\tfrac{5}{2}A_{,}^4+\qquad)-(\beta_1^o)^2A_{,}\}\cos\beta^o\\
&-\Sigma R^a_{h,j}\quad\Big\{\Big\{\Big([h+2]+2j\frac{m}{a_1}\Big)\cos a\qquad -m\frac{[h+1]\,c'-jc''}{a_1+\gamma_1}\cos(a+\gamma)\qquad +m\frac{[h+1]\,c'+jc''}{a_1-\gamma_1}\cos(a-\gamma)\qquad\Big\}\\
&\quad+\frac{1}{2}\Big\{\Big(1-hA_{,}+(h+\tfrac{1}{2}h\,[h-1])\,A_{,}^2-(h+h\,[h-1]+\tfrac{1}{6}h\,[h-1]\,[h-2])\,A_{,}^3+\qquad\Big)\Big(1+jA_v-\tfrac{1}{2}j^2A_v^2-\tfrac{1}{6}j^3A_v^3+\qquad\Big)-1\Big\}\\
&\qquad\Big\{\Big([h+2]+2j\frac{m}{a_1+\beta_1}\Big)\cos(a+\beta)\qquad -m\frac{[h+1]\,c'-jc''}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)\qquad +m\frac{[h+1]\,c'+jc''}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\qquad\Big\}\\
&\quad+\frac{1}{2}\Big\{\Big(1-hA_{,}+(h+\tfrac{1}{2}h\,[h-1])\,A_{,}^2-(h+h\,[h-1]+\tfrac{1}{6}h\,[h-1]\,[h-2])\,A_{,}^3+\qquad\Big)\Big(1-jA_v-\tfrac{1}{2}j^2A_v^2+\tfrac{1}{6}j^3A_v^3+\qquad\Big)-1\Big\}\\
&\qquad\Big\{\Big([h+2]+2j\frac{m}{a_1-\beta_1}\Big)\cos(a-\beta)\qquad -m\frac{[h+1]\,c'-jc''}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)\qquad +m\frac{[h+1]\,c'+jc''}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\qquad\Big\}\Big\}\\
&-\Sigma Z^a_{(h+1),j}\Big\{\frac{1}{2}\{A_z\Big(1-[h+1]\,A_{,}+([h+1]+\tfrac{1}{2}h\,[h+1])\,A_{,}^2-\qquad\Big)\Big(1+jA_{\iota}-\tfrac{1}{2}j^2A_v^2-\qquad\Big)\}\qquad\qquad(E)\\
&\qquad\Big\{\Big([h+3]+2j\frac{m}{a_1'+\beta_1'}\Big)\cos(a'+\beta')\quad -m\frac{[h+2]\,c'-jc''}{a_1'+\beta_1'+\gamma_1}\cos(a'+\beta'+\gamma')+m\frac{[h+2]\,c'+jc''}{a_1'+\beta_1'-\gamma_1}\cos(a'+\beta'-\gamma)\quad\Big\}\\
&\quad+\frac{1}{2}\{A_z\Big(1-[h+1]\,A_{,}+([h+1]+\tfrac{1}{2}h\,[h+1])\,A_{,}-\qquad\Big)\Big(1-jA_{\iota}-\tfrac{1}{2}j^2A_{\iota}^2-\qquad\Big)\}\\
&\qquad\Big\{\Big([h+3]+2j\frac{m}{a_1'-\beta_1'}\Big)\cos(a'-\beta')\quad -m\frac{[h+2]\,c'-jc''}{a_1'-\beta_1'+\gamma_1}\cos(a'-\beta'+\gamma)\;+m\frac{[h+2]\,c'+jc''}{a_1'-\beta_1'-\gamma}\cos(a'-\beta'-\gamma)\quad\Big\}\Big\}\\
&-\Sigma Z^a_{h,j}\quad\Big\{\frac{1}{2}\{A_z^2\Big(1-[h]\,A_{,}+\qquad\Big)\Big(1+jA_{\iota}-\qquad\Big)\}\\
&\qquad\Big\{\Big([h+2]+2j\frac{m}{a_1''+\beta_1''}\Big)\cos(a'+\beta'')-m\frac{[h+1]\,c'-jc''}{a_1'+\beta_1'+\gamma_1}\cos(a''+\beta''+\gamma)+m\frac{[h+1]\,c'+jc''}{a_1''+\beta_1''-\gamma_1}\cos(a''+\beta''-\gamma)\Big\}\\
&\quad+\frac{1}{2}\{A_z^2\Big(1-[h]\,A_{,}+\qquad\Big)\Big(1-jA_{\iota}-\qquad\Big)\}\\
&\qquad\Big\{\Big([h+2]+2j\frac{m}{a_1''-\beta_1''}\Big)\cos(a\;\;-\beta\;\;)-m\frac{[h+1]\,c'-jc''}{a_1''-\beta_1''+\gamma_1}\cos(a''-\beta''+\gamma)+m\frac{[h+1]\,c'+jc''}{a_1''-\beta_1''-\gamma_1}\cos(a''-\beta''-\gamma)\Big\}\Big\}
\end{aligned}
$$

It is only necessary to put for l and j their proper numerical values, and the above expression will give the complete value of the differential equation in general terms

The differential equation to ψ next requires consideration, and this may be reduced to a very similar form to the above in a very similar manner. Let

$$\psi_o = \mathrm{G} \sin \xi^o, \tag{20}$$

the above being the general term, then, from Eq 15, § 5, writing the integrating factors on the same principle as before,

$$\mathrm{F}(\psi_o) = \{(\xi_1^o)^2 - 1\} \mathrm{G} \sin \xi^o \tag{21}$$

The series of which the general term is $\mathrm{G} \sin \xi^o$ may be regarded as a small portion of the larger series for $\delta\psi$, of which the general term is

$$\delta\psi = \mathrm{A}_\psi \sin \xi \tag{22}$$

Supposing then this smaller series incorporated in the terms of the same arguments in the larger series, and put on the same principle of notation as before,

$$f(r) = 1 - \mathrm{U}^3 \{1 + 3\mathrm{A}_{,} + 3\mathrm{A}_{,}^2 + \mathrm{A}_{,}^3\} \cos \beta, \tag{23}$$

and the second term in the differential equation to ψ becomes

$$\begin{aligned}\{\psi_o + \delta\psi\} f(r) = \mathrm{A}_\psi \sin \xi - \frac{1}{2} \mathrm{A}_\psi \mathrm{U}^3 \{1 + 3\mathrm{A}_{,} + 3\mathrm{A}_{,}^2 + \mathrm{A}_{,}^3\} \sin (\xi + \beta) \\ - \frac{1}{2} \mathrm{A}_\psi \mathrm{U}^3 \{1 + 3\mathrm{A}_{,} + 3\mathrm{A}_{,}^2 + \mathrm{A}_{,}^3\} \sin (\xi - \beta)\end{aligned} \tag{24}$$

Considering the last term of Equation 17, § 5,

$$\begin{aligned}\frac{d\mathrm{R}}{d\psi} = \frac{d\mathrm{R}^o}{d\psi_o} + \left\{\frac{d^2\mathrm{R}^o}{dr_o d\psi_o} \delta r + \frac{d^2\mathrm{R}^o}{dv_o d\psi_o} \delta v + \frac{d^2\mathrm{R}^o}{d\psi_o^2} \delta\psi\right\} \\ + \frac{1}{2}\left\{\frac{d^3\mathrm{R}^o}{dr_o^2 d\psi_o} (\delta r)^2 + 2 \frac{d^3\mathrm{R}^o}{dr_o dv_o d\psi_o} \delta r \, \delta v + \frac{d^3\mathrm{R}^o}{dv_o^2 d\psi_o} (\delta v)^2 + 2 \frac{d^3\mathrm{R}^o}{dr_o^2 d\psi_o^2} \delta r \, \delta\psi + 2 \frac{d^3\mathrm{R}^o}{dv_o d\psi_o^2} \delta v \, \delta\psi \right. \\ \left. + \frac{d^3\mathrm{R}^o}{d\psi_o^3} (\delta\psi)^2\right\} + \end{aligned} \tag{25}$$

Putting for the different differential coefficients the values which have been already found for them, and for δr its value in terms of $\delta \frac{1}{r}$, and the above expression becomes

$$
\begin{aligned}
\frac{dR}{d\psi} = {} & \sin\lambda_o \Sigma \Big\{ 1 - [\lambda+1] \left(r_o\delta\frac{1}{r}\right) \quad + \left([\lambda+1] + \tfrac{1}{2}[\lambda+1]\ \lambda\right) \left(r_o\delta\frac{1}{r}\right)^2 \\
& - \left([\lambda+1] + [\lambda+1]\ \lambda + \tfrac{1}{6}[\lambda+1]\ \lambda\ [\lambda-1]\right) \left(r_o\delta\frac{1}{r}\right)^3 - \ \cdot \quad - \tfrac{1}{2} j^2 (\delta v)^2 + \qquad \Big\}\ [Z^{o}_{(\lambda+1),j}]_{\cos} \\
& + \sin\lambda_o \Sigma \Big\{ -j \Big(1 - [\lambda+1] \left(r_o\delta\frac{1}{r}\right) + \left([\lambda+1] + \tfrac{1}{2}[\lambda+1]\ \lambda\right) \left(r_o\delta\frac{1}{r}\right)^2 - \qquad \Big)\ \delta v \\
& \qquad\qquad + \tfrac{1}{6} j^3 \delta v^3 - \qquad \Big\}\ [Z^{o}_{(\lambda+1),j}]_{\sin} \\
& + \delta\psi\ \Sigma\ \Big\{ 1 - [\lambda] \left(r_o\delta\frac{1}{r}\right) \quad + \left([\lambda] \quad + \tfrac{1}{2}[\lambda-1]\ \lambda\right) \left(r_o\delta\frac{1}{r}\right)^2 - \qquad\qquad (26) \\
& \qquad\qquad - \tfrac{1}{2} j^2 (\delta v)^2 + \qquad \Big\}\ [Z^{o}_{\lambda,j}]_{\cos} \\
& + \delta\psi\ \Sigma\ \Big\{ -j \Big(1 - [\lambda] \left(r_o\delta\frac{1}{r}\right) \quad + \left([\lambda] \quad + \tfrac{1}{2}[\lambda-1]\ \lambda\right) \left(r_o\delta\frac{1}{r}\right)^2 - \ \cdot\cdot\ \Big)\ \delta v \\
& \qquad\qquad + \qquad \Big\}\ [Z^{o}_{\lambda,j}]_{\sin} \\
& +
\end{aligned}
$$

The terms depending on $(\delta\psi)^2$ involve as a coefficient $\frac{d^3R}{d\psi^3}$ or its differentials with regard to r and v, and these are so small that it is assumed they can be neglected.

Let the following general expressions be adopted:—

$$\sin\lambda_o\ [Z^{o}_{(\lambda+1),j}]_{\cos} = \quad Z^{a}_{(\lambda+1),j}\ G\ \sin\pi, \tag{27}$$

$$\sin\lambda_o\ [Z^{o}_{(\lambda+1),j}]_{\sin} = -Z^{a}_{(\lambda+1),j}\ G\ \cos\pi, \tag{28}$$

$$(\delta\psi)\ [Z^{o}_{\lambda,j}]_{\cos} = \quad Z^{a}_{\lambda,j}\ A_{\psi} \sin\pi', \tag{29}$$

$$(\delta\psi)\ [Z^{o}_{\lambda,j}]_{\sin} = -Z^{a}_{\lambda,j}\ A_{\psi} \cos\pi' \tag{30}$$

Substituting these expressions, together with those previously defined, and

$$\frac{dR}{d\psi} = G\Sigma\, Z^{o}_{(\lambda+1),r}\left\{\frac{1}{2}\left\{\left(1-[\lambda+1]\,A_r+\left([\lambda+1]+\frac{1}{2}[\lambda]\,[\lambda+1]\right)A_r^2-\left([\lambda+1]+\lambda\,[\lambda+1]+\frac{1}{6}\lambda\,[\lambda+1]\,[\lambda-1]\right)A_r^3+\ \cdot\ \right)\right.\right.$$

$$\left.\left(1+jA_v-\frac{1}{2}j^2A_v^2-\frac{1}{6}j^3A_v^3+\ \cdot\ \right)\right\}\sin(\pi+\beta)$$

$$+\frac{1}{2}\left\{\left(1-[\lambda+1]\,A_r+\left([\lambda+1]+\frac{1}{2}\lambda\,[\lambda+1]\right)A_r^2-\left([\lambda+1]+\lambda\,[\lambda+1]+\frac{1}{6}\lambda\,[\lambda+1]\,[\lambda-1]\right)A_r^3+\qquad\right)\right.$$

$$\left.\left(1-jA_v-\frac{1}{2}j^2A_v^2+\frac{1}{6}j^3A_v^3+\qquad\right)\right\}\sin(\pi-\beta)$$

$$+A_\gamma\Sigma\, Z^{o}_{\lambda,r}\left\{\frac{1}{2}\left\{\left(1-\lambda A_r+\left(\lambda+\frac{1}{2}\lambda\,[\lambda-1]\right)A_r^2-\qquad\right)\left(1+jA_v-\frac{1}{2}j^2A_\iota^2-\qquad\right)\right\}\sin(\pi'+\beta)\right. \qquad (31)$$

$$\left.+\frac{1}{2}\left\{\left(1-\lambda A_r+\left(\lambda+\frac{1}{2}\lambda\,[\lambda-1]\right)A_r^2-\qquad\right)\left(1-jA_\iota+\frac{1}{2}j^2A_\iota^2-\qquad\right)\right\}\sin(\pi'-\beta)\right\}$$

Therefore, uniting the three portions (21) (24) and (31)

$$\frac{d^2\delta\psi}{dt^2}+\mu\delta\psi = \{(\xi^o_1)^2-1\}\,G\sin\xi^{o\prime\prime}$$

$$+\left\{A_\psi\sin\xi-\frac{1}{2}A_\gamma U^3\left(1+3A_r+3A_r^2+A_r^3\right)\sin(\xi+\beta)-\frac{1}{2}A_\gamma U^3\left(1+3A_r+3A_r^2+A_r^3\right)\sin(\xi-\beta)\right\}$$

$$+G\Sigma\, Z^{o}_{(\lambda+1),j}\left\{\frac{1}{2}\left\{\left(1-[\lambda+1]\,A_r+\left([\lambda+1]+\frac{1}{2}\lambda\,[\lambda+1]\right)A_r^2-\left([\lambda+1]+\lambda\,[\lambda+1]+\frac{1}{6}\lambda\,[\lambda+1]\,[\lambda-1]\right)A_r^3+\cdot\qquad\right)\right.\right.$$

$$\left.\left(1+jA_\iota-\frac{1}{2}j^2A_\iota^2-\frac{1}{6}j^3A_\iota^3-\qquad\right)\right\}\sin(\pi+\beta)$$

$$+\frac{1}{2}\left\{\left(1-[k+1]\,A_r+\left([\lambda+1]+\frac{1}{2}\lambda\,[\lambda+1]\right)A_r^2-\left([\lambda+1]+\lambda\,[\lambda+1]+\frac{1}{6}\lambda\,[k+1]\,[\lambda-1]\right)A_r^3+\qquad\right)\right.$$

$$\left.\left.\left(1-jA_v-\frac{1}{2}j^2A_v^2-\frac{1}{6}j^3A_\iota^3+\qquad\right)\right\}\sin(\pi-\beta)\right\} \qquad (F)$$

$$+A_\psi\Sigma.Z^{o}_{\lambda,j}\left\{\frac{1}{2}\left\{\left(1-\lambda A_r+\left(\lambda+\frac{1}{2}\lambda\,[\lambda-1]\right)A_r^2-\ldots\right)\left(1+jA_\iota-\frac{1}{2}j^2A_\iota^2-\qquad\right)\right\}\sin(\pi'+\beta)\right.$$

$$\left.+\frac{1}{2}\left\{\left(1-\lambda A_r+\left(\lambda+\frac{1}{2}\lambda\,[\lambda-1]\right)A_r^2-\qquad\right)\left(1-jA_r-\frac{1}{2}j^2A_r^2-\qquad\right)\right\}\sin(\pi'-\beta)\right\}$$

The above forms the complete development of the differential equation for $\delta\psi$ As a matter of fact, the two series of arguments, distinguished as π and π', are identical, so that these last two groups could have been united into one They are more convenient, however, in their present form

It only remains to reduce the differential equation for the Moon's longitude to the same form as the two others Put

$$\frac{1}{r_o^2}\left\{1+2\left[r_o\delta\frac{1}{r}\right]+\left[r_o\delta\frac{1}{r}\right]^2\right\}=U^2\,(1+A_r)^2\cos\omega, \tag{32}$$

$$\frac{1}{r_o^2}\{\psi_o^2+2\psi_o\,(\delta\psi)+(\delta\psi)^2\}\;=U^2\,(G+A_\psi)^2\cos\omega \tag{33}$$

Then, on the same principle of notation as has been previously adopted, the differential equation becomes

$$\frac{dv}{dt}=U^2\{(1+A_r)^2+U^2\,(G+A_\psi)^2\,(1+A_r)^4-U^4\,(G+A_\psi)^4\,(1+A_r)^6+U^6\,(G+A_\psi)^6\,(1+A_r)^8$$
$$-U^8\,(G+A_\psi)^8\,(1+A_r)^{10}+\qquad\}\,\{h-\int\Sigma_j\,[R^o_{i,j}]_{\sin}\,dt\}\cos\omega$$

Putting for the function under the integral the value which has been already found for it,

$$-\int\Sigma_j\,[R_{i,j}]_{\sin}\,dt=\;\Sigma R^o_{i,j}\;\left\{\frac{j}{\alpha_1}\cos\alpha+\;\overset{+}{A}_{i,j}\frac{j}{\alpha_1+\beta_1}\cos(\alpha+\beta)\right.$$
$$\left.+\;\bar{A}_{k,j}\frac{j}{\alpha_1-\beta_1}\cos(\alpha-\beta)\right\}$$
$$+\Sigma Z^a_{[k+1],j}\{\qquad+A\;\overset{+}{A}_{[k+1],j}\frac{j}{\alpha_1'+\beta_1'}\cos(\alpha'+\beta')$$
$$+A\;\bar{A}_{[l+1],j}\frac{j}{\alpha_1'-\beta_1'}\cos(\alpha_1'-\beta_1')\} \tag{34}$$
$$+\Sigma Z^a_{k,j}\quad\{\qquad+A_2^2\overset{+}{A}_{l,j}\frac{j}{\alpha_1''-\beta_1''}\cos(\alpha''+\beta'')$$
$$+A_2^2\bar{A}_{l,j}\frac{j}{\alpha_1''-\beta_1''}\cos(\alpha''-\beta'')\;\}$$

The above value of ω includes the value 0, exclude this last value, and combine the two terms, and

$$
\begin{aligned}
\frac{dv}{dt} = h + U^2\{(1+A_{,})^2 + U^2(G+A_{\psi})^2(1+A_{,})^4 - U^4(G+A_{\psi})^4(1+A_{,})^6 + U^6(G+A_{\psi})^6(1+A_{,})^8 \\
- U^8(G+A_{\psi})^8(1+A_{,})^{10}\}\, h \cos\omega \\
+ \Sigma R''_{j,}\left\{\frac{j}{\alpha_1}\cos\alpha + \overset{+}{A}_{j,}\frac{j}{\alpha_1+\beta_1}\cos(\alpha+\beta) + \bar{A}_{j,}\frac{j}{\alpha_1-\beta_1}\cos(\alpha-\beta)\right\} \\
+ \Sigma Z''_{[k+1],}A\ \{\overset{+}{A}_{[j+1],}\frac{j}{\alpha_1'+\beta_1'}\cos(\alpha'+\beta') + \bar{A}_{[j+1],}\frac{j}{\alpha_1'-\beta_1'}\cos(\alpha'-\beta')\} \\
+ \Sigma Z''_{k,}A_z^2\ \{\overset{+}{A}_{j,}\frac{j}{\alpha_1''+\beta_1''}\cos(\alpha''+\beta'') + \bar{A}_{k,}\frac{j}{\alpha_1''-\beta_1''}\cos(\alpha''-\beta'')\} \qquad (G) \\
+ \frac{1}{2}U^2\{(1+A_{,})^2 + U^2(G+A_{\psi})^2(1+A_{,})^4 - U^4(G+A_{\psi})^4(1+A_{,})^6 + U^6(G+A_{\psi})^6(1+A_{,})^8\} \\
\Big\{\Sigma R''_{j,}\Big\{\frac{j}{\alpha_1}[\cos(\alpha+\omega)+\cos(\alpha-\omega)] + \overset{+}{A}_{j,}\frac{j}{\alpha_1+\beta_1}[\cos(\alpha+\beta+\omega)+\cos(\alpha+\beta-\omega)] \\
+ \bar{A}_{j,}\frac{j}{\alpha_1-\beta_1}[\cos(\alpha-\beta+\omega)+\cos(\alpha-\beta-\omega)]\Big\} \\
+ \Sigma Z''_{[j+1],}A\ \{\overset{+}{A}_{[j+1],}\frac{j}{\alpha_1'+\beta_1'}[\cos(\alpha'+\beta'+\omega)+\cos(\alpha'+\beta'-\omega)] \\
+ \bar{A}_{[j+1],}\frac{j}{\alpha_1'-\beta_1'}[\cos(\alpha'-\beta'+\omega)+\cos(\alpha'-\beta'-\omega)]\} \\
+ \Sigma Z^{a}_{k,}A_z^2\ \{\overset{+}{A}_{j,}\frac{j}{\alpha_1''+\beta_1''}[\cos(\alpha''+\beta''+\omega)+\cos\alpha''+\beta''-\omega)] \\
+ \bar{A}_{j,}\frac{j}{\alpha_1''-\beta_1''}[\cos(\alpha''-\beta''+\omega)+\cos(\alpha''-\beta''-\omega)]\}\Big\}
\end{aligned}
$$

§ 7.

To complete the development of the three differential equations, it is only necessary to give to k and j in succession their proper numerical values These values will be given by the equations B, on page 11, and C, on page 14

Then the final form of the differential equation to the radius vector becomes

$$\frac{d^2\delta\frac{1}{r}}{dt^2}+\delta\frac{1}{r}=\{1-(\beta_1^0)^2\}\,U^2\cos\beta^0+\beta_1^2\,\{U^2\,(A_{,}-\tfrac{3}{2}A_{,}^2+2A_{,}^3-\tfrac{5}{2}A_{,}^4+\qquad)-A_{,}\}\cos\beta$$

$$-R^{a}_{20}\Big\{\Big\{4\cos a\qquad -m\frac{3c'}{a_1+\gamma_1}\cos(a+\gamma)\;+m\frac{3c'}{a_1-\gamma_1}\cos(a-\gamma)\Big\}$$

$$+\frac{1}{2}\Big\{(-2A_{,}+3A_{,}^2-4A_{,}^3)\Big\}\Big\{4\cos(a+\beta)-m\frac{3c'}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)+m\frac{3c'}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\Big\}$$

$$+\frac{1}{2}\Big\{(-2A_{,}+3A_{,}^2-4A_{,}^3)\Big\}\Big\{4\cos(a-\beta)-m\frac{3c'}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)+m\frac{3c'}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\Big\}\Big\}$$

$$-R^{a}_{22}\Big\{\Big\{\Big(4+4\frac{m}{a_1}\Big)\cos a-m\frac{3c'-2c''}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{3c'+2c''}{a_1-\gamma_1}\cos(a-\gamma)\Big\}$$

$$+\frac{1}{2}\Big\{(1-2A_{,}+3A_{,}^2-4A_{,}^3)\,(1+2A_{,}-2A_{,}^2-\tfrac{4}{3}A_{,}^3)-1\Big\}\Big\{\Big(4+4\frac{m}{a_1+\beta_1}\Big)\cos(a+\beta)-m\frac{3c'-2c''}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)$$
$$+m\frac{3c'+2c''}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\Big\}$$

$$+\frac{1}{2}\Big\{(1-2A_{,}+3A_{,}^2-4A_{,}^3)\,(1-2A_{,}-2A_{,}^2+\tfrac{4}{3}A_{,}^3)-1\Big\}\Big\{\Big(4+4\frac{m}{a_1-\beta_1}\Big)\cos(a-\beta)-m\frac{3c'-2c''}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)$$
$$+m\frac{3c'+2c''}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\Big\}\Big\}$$

$$-R^a_{31}\left\{\left\{\left(5+2\frac{m}{a_1}\right)\cos a-m\frac{4c'-c''}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{4c'+c''}{a_1-\gamma_1}\cos(a-\gamma)\right\}\right.$$

$$+\frac{1}{2}\Big\{(1-3A_r+6A_r^2-\quad)(1+A_v-\frac{1}{2}A_v^2-\quad)-1\Big\}\left\{\left(5+2\frac{m}{a_1+\beta_1}\right)\cos(a+\beta)-m\frac{4c'-c''}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)\right.$$
$$\left.+m\frac{4c'+c''}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\right\}$$

$$+\frac{1}{2}\Big\{(1-3A_r+6A_r^2-\quad)(1-A_v-\frac{1}{2}A_v^2+\quad)-1\Big\}\left\{\left(5+2\frac{m}{a_1-\beta_1}\right)\cos(a-\beta)-m\frac{4c'-c''}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)\right.$$
$$\left.\left.+m\frac{4c'+c''}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\right\}\right\}$$

$$-R^a_{33}\left\{\left\{\left(5+6\frac{m}{a_1}\right)\cos a-m\frac{4c'-3c''}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{4c'+3c''}{a_1-\gamma_1}\cos(a-\gamma)\right\}\right.$$

$$+\frac{1}{2}\Big\{(1-3A_r+6A_r^2-\quad)(1+3A_v-\frac{9}{2}A_v^2-\quad)-1\Big\}\left\{\left(5+6\frac{m}{a_1+\beta_1}\right)\cos(a+\beta)-m\frac{4c'-3c''}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)\right.$$
$$\left.+m\frac{4c'+3c''}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\right\}$$

$$+\frac{1}{2}\Big\{(1-3A_r+6A_r^2-\quad)(1-3A_v-\frac{9}{2}A_v^2-\quad)-1\Big\}\left\{\left(5+6\frac{m}{a_1-\beta_1}\right)\cos(a-\beta)-m\frac{4c'-3c''}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)\right.$$
$$\left.\left.+m\frac{4c'+3c''}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\right\}\right\}$$

$$-R^a_{40}\left\{\left\{6\cos a\quad-m\frac{5c'}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{5c'}{a_1-\gamma_1}\cos(a-\gamma)\right\}\right.$$

$$+\frac{1}{2}\Big\{(1-4A_r+\quad)(1\quad)-1\Big\}\left\{6\cos(a+\beta)-m\frac{5c'}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)+m\frac{5c'}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\right\}$$

$$\left.+\frac{1}{2}\Big\{(1-4A_r+\quad)(1\quad)-1\Big\}\left\{6\cos(a-\beta)-m\frac{5c'}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)+m\frac{5c'}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\right\}\right\}$$

$$\begin{aligned}
&-\mathrm{R}^{a}_{42}\left\{\left\{\left(6+4\frac{m}{a_1}\right)\cos a-m\frac{5c'-2c''}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{5c'+2c''}{a_1-\gamma_1}\cos(a-\gamma)\right\}\right. \qquad \text{(H)}\\
&+\frac{1}{2}\left\{(1-4\mathrm{A}_r+\dots)(1+2\mathrm{A}_v-\dots)-1\right\}\left\{\left(6+4\frac{m}{a_1+\beta_1}\right)\cos(a+\beta)-m\frac{5c'-2c''}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)\right.\\
&\qquad\qquad\left.+m\frac{5c'+2c''}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\right\}\\
&+\frac{1}{2}\left\{(1-4\mathrm{A}_r+\dots)(1-2\mathrm{A}_\iota-\dots)-1\right\}\left\{\left(6+4\frac{m}{a_1-\beta_1}\right)\cos(a-\beta)-m\frac{5c'-2c''}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)\right.\\
&\qquad\qquad\left.\left.+m\frac{5c'+2c''}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\right\}\right\}\\
&-\mathrm{R}^{a}_{44}\left\{\left\{\left(6+8\frac{m}{a_1}\right)\cos a-m\frac{5c'-4c''}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{5c'+4c''}{a_1-\gamma_1}\cos(a-\gamma)\right\}\right.\\
&+\frac{1}{2}\left\{(1-4\mathrm{A}_r+\dots)(1+4\mathrm{A}_\iota-\dots)-1\right\}\left\{\left(6+8\frac{m}{a_1+\beta_1}\right)\cos(a+\beta)-m\frac{5c'-4c''}{a_1+\beta_1+\gamma_1}\cos(a+\beta+\gamma)\right.\\
&\qquad\qquad\left.+m\frac{5c'+4c''}{a_1+\beta_1-\gamma_1}\cos(a+\beta-\gamma)\right\}\\
&+\frac{1}{2}\left\{(1-4\mathrm{A}_r+\dots)(1-4\mathrm{A}_\iota-\dots)-1\right\}\left\{\left(6+8\frac{m}{a_1-\beta_1}\right)\cos(a-\beta)-m\frac{5c'-4c''}{a_1-\beta_1+\gamma_1}\cos(a-\beta+\gamma)\right.\\
&\qquad\qquad\left.\left.+m\frac{5c+4c''}{a_1-\beta_1-\gamma_1}\cos(a-\beta-\gamma)\right\}\right\}
\end{aligned}$$

$$-R^a_{51}\left\{\left(7+2\frac{m}{a_1}\right)\cos a\ -m\frac{6c'-c''}{a_1+\gamma_1}\cos(a+\gamma)\ +m\frac{6c'+c''}{a_1-\gamma_1}\cos(a-\gamma)\ \right\}$$

$$-R^a_{53}\left\{\left(7+6\frac{m}{a_1}\right)\cos a\ -m\frac{6c'-3c''}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{6c'+3c''}{a_1-\gamma_1}\cos(a-\gamma)\right\}$$

$$-R^a_{55}\left\{\left(7+10\frac{m}{a_1}\right)\cos a-m\frac{6c'-5c''}{a_1+\gamma_1}\cos(a+\gamma)+m\frac{6c'+5c''}{a_1-\gamma_1}\cos(a-\gamma)\right\}$$

$$-Z^a_{10}\left\{\frac{1}{2}\{A_{\sim}(1-A_{,})\}\{(3)\cos(a'+\beta')-m\frac{2c'}{a_1'+\beta_1'+\gamma_1'}\cos(a'+\beta'+\gamma')+m\frac{2c'}{a_1'+\beta_1'-\gamma_1}\cos(a'+\beta'-\gamma)\}\right.$$

$$\left.+\frac{1}{2}\{A_z(1-A_{,})\}\{(3)\cos(a'-\beta')-m\frac{2c'}{a_1'-\beta_1'+\gamma_1}\cos(a'-\beta'+\gamma)+m\frac{2c'}{a_1'-\beta_1'-\gamma_1}\cos(a'-\beta'-\gamma')\}\right\}$$

$$-Z^a_{21}\left\{\frac{1}{2}\left\{A_z(1-2A_{,}-\qquad)(1+A_{\iota}-\qquad)\right\}\left\{\left(4+2\frac{m}{a_1'+\beta_1'}\right)\cos(a'+\beta')-m\frac{3c'-c''}{a_1'+\beta_1'+\gamma_1}\cos(a'+\beta'+\gamma)\right.\right.$$

$$\left.+m\frac{3c'+c''}{a_1'+\beta_1'-\gamma_1}\cos(a_1'+\beta_1'-\gamma)\right\}$$

$$+\frac{1}{2}\left\{A_{\sim}(1-2A_{,}-\qquad)(1-A_v-\ ..\quad)\right\}\left\{\left(4+2\frac{m}{a_1'-\beta_1'}\right)\cos(a'-\beta')-m\frac{3c'-c''}{a_1'-\beta_1'+\gamma_1}\cos(a'-\beta'+\gamma)\right.$$

$$\left.\left.+m\frac{3c'+c''}{a_1'-\beta_1'+\gamma_1}\cos(a'-\beta'-\gamma)\right\}\right\}$$

$$-Z^a_{30}\left\{\frac{1}{2}\{A_{\sim}(1-\qquad)\}\{(5)\cos(a'+\beta')-m\frac{4c'}{a_1'+\beta_1'+\gamma_1}\cos(a'+\beta'+\gamma)+m\frac{4c'}{a_1'+\beta_1'-\gamma}\cos(a'+\beta'-\gamma)\ \}\right.$$

$$\left.+\frac{1}{2}\{A\ (1-\qquad)\}\{(5)\cos(a'-\beta')-m\frac{4c'}{a_1'-\beta_1'+\gamma_1}\cos(a'-\beta'+\gamma)+m\frac{4c'}{a_1'-\beta_1'-\gamma_1}\cos(a'-\beta'-\gamma)\}\right\}$$

$$-Z^{a}_{32}\left\{\frac{1}{2}\left\{A_{z}\,(1- \qquad)\,(1+ \quad\cdot \qquad)\right\}\left\{\left(5+4\frac{m}{a_1'+\beta_1'}\right)\cos(a'+\beta') \quad -m\frac{4c'-2c''}{a_1'+\beta_1'+\gamma_1}\cos(a'+\beta'+\gamma)\right.\right.$$

$$\left. +m\frac{4c'+2c''}{a_1'+\beta_1'-\gamma_1'}\cos(a'+\beta'-\gamma)\right\}$$

$$+\frac{1}{2}\left\{A_{z}\,(1- \qquad)\,(1- \qquad)\right\}\left\{\left(5+4\frac{m}{a_1'-\beta_1'}\right)\cos(a'-\beta') \quad -m\frac{4c'-2c''}{a_1'-\beta_1'+\gamma_1}\cos(a'-\beta'+\gamma)\right.$$

$$\left.\left. +m\frac{4c'+2c''}{a_1'-\beta_1'-\gamma_1}\cos(a'-\beta'-\gamma)\right\}\right\}$$

$$-Z^{a}_{11}\left\{\frac{1}{2}\left\{A_{z}^{2}\,(1- \qquad)\,(1+ \quad\cdot \qquad)\right\}\left\{\left(3+2\frac{m}{a_1''+\beta_1''}\right)\cos(a''+\beta'')-m\frac{2c'-c''}{a_1''+\beta_1''+\gamma_1}\cos(a''+\beta''+\gamma)\right.\right.$$

$$\left. +m\frac{2c'+c''}{a_1''+\beta_1''-\gamma_1}\cos(a''+\beta''-\gamma)\right\}$$

$$+\frac{1}{2}\left\{A_{z}^{2}\,(1- \qquad)\,(1- \qquad)\right\}\left\{\left(3+2\frac{m}{a_1''-\beta_1'}\right)\cos(a''-\beta'')-m\frac{2c'-c''}{a_1''-\beta_1''+\gamma_1}\cos(a''-\beta''+\gamma)\right.$$

$$\left.\left. +m\frac{2c'+c}{a_1''-\beta_1''-\gamma_1}\cos(a''-\beta''-\gamma)\right\}\right\}$$

$$+$$

In the same manner the differential equation to the variable ψ is, when completely developed, as follows —

$$
\begin{array}{llll}
\frac{d^2\delta\psi}{dt^2}+\delta\psi = & \{(\xi_1^o)^2-1\}G\sin\xi^o & & \\
 & +\Big\{A_\psi\sin\xi-\frac{1}{2}A_\psi U^3\,(1+3A_{,}+3A_r^2+A_{,}^3)\sin(\xi+\beta) & & \\
 & \qquad -\frac{1}{2}A_\psi U^3\,(1+3A_{,}+3A_{,}^2+A_r^3)\sin(\xi-\beta)\Big\} & & \\
+G\,Z^o_{10}\Big\{\frac{1}{2}\{(1-A_{,}+A_{,}^2-A_r^3- &)\,(1 &)\}\sin(\pi+\beta) & \\
\qquad +\frac{1}{2}\{(1-A_r+A_r^2-A_{,}^3- &)\,(1 &)\}\sin(\pi-\beta)\Big\} & \\
+G\,Z^o_{21}\Big\{\frac{1}{2}\{(1-2A_r+3A_{,}^2- &)\,(1+A_v-\frac{1}{2}A_v^2- &)\}\sin(\pi+\beta) & \\
\qquad +\frac{1}{2}\{(1-2A_r+3A_{,}^2- &)\,(1-A_{,}-A_{,}^2- &)\}\sin(\pi-\beta)\Big\} & \\
+G\,Z^o_{30}\Big\{\frac{1}{2}\{(1-3A_r+ &)\,(1 &)\}\sin(\pi+\beta) & \\
\qquad +\frac{1}{2}\{(1-3A_r+ &)\,(1 &)\}\sin(\pi-\beta)\Big\} & (\mathrm{I}) \\
+G\,Z^o_{32}\Big\{\frac{1}{2}\{(1-3A_r+ &)\,(1+2A_{,}- &)\}\sin(\pi+\beta) & \\
\qquad +\frac{1}{2}\{(1-3A_{,}+ &)\,(1-3A_v- &)\}\sin(\pi-\beta)\Big\} & \\
+A_\psi\,Z^o_{00}\Big\{\quad\sin\pi' & & \Big\} & \\
+A_\psi\,Z^o_{10}\Big\{\frac{1}{2}\{(1-A_r+ &) & \}\sin(\pi'+\beta) & \\
\qquad +\frac{1}{2}\{(1-A_r+ &) & \}\sin(\pi'-\beta)\Big\} & \\
+A_\psi\,Z^o_{21}\Big\{\frac{1}{2}\{(1- &)\,(1+\quad\cdot &)\}\sin(\pi'+\beta)^* & \\
\qquad +\frac{1}{2}\{(1- &)\,(1+ &)\}\sin(\pi'-\beta)^*\Big\} & \\
\qquad + & & &
\end{array}
$$

---

* As there are no terms in $A_{,}$ or A_v, the factor β is also zero, so these two terms are really the single term $\sin\pi'$

Finally, the differential equation to the Moon's longitude is

$$\frac{dl}{dt}=U^2\{(1+A_{,})^2+U^2(G+A_\psi)^2(1+A_{,})^4-U^4(G+A_\psi)^4(1+A_{,})^6+U^6(G+A_\psi)^6(1+A_{,})^8$$

$$-U^8(G+A_\psi)^8(1+A_{,})^{10}+\qquad\quad\}h\cos\omega+h$$

$$+R^{a}_{22}\left\{\frac{2}{\alpha_1}\cos\alpha+\frac{1}{\alpha_1+\beta_1}\{(1-2A_r+3A_{,}^2-4A_{,}^3)\ (1+2A_v-2A_v^2-\frac{4}{3}A_v^3)-1\}\cos(\alpha+\beta)\right.$$

$$\left.+\frac{1}{\alpha_1-\beta_1}\{(1-2A_{,}+3A_{,}^2-4A_{,}^3)\ (1-2A_v-2A_v^2+\frac{4}{3}A_v^3)-1\}\cos(\alpha-\beta)\right\}$$

$$+R^{a}_{31}\left\{\frac{1}{\alpha_1}\cos\alpha+\frac{\frac{1}{2}}{\alpha_1+\beta_1}\{(1-3A_{,}+6A_{,}^2-\qquad)\ (1+A_{\iota}-\frac{1}{2}A_v^2-\qquad)-1\}\cos(\alpha+\beta)\right.$$

$$\left.+\frac{\frac{1}{2}}{\alpha_1-\beta_1}\{(1-3A_{,}+6A_{,}^2-\qquad)\ (1-A_v-\frac{1}{2}A_v^2-\qquad)-1\}\cos(\alpha-\beta)\right\}$$

$$+R^{a}_{33}\left\{\frac{3}{\alpha_1}\cos\alpha+\frac{\frac{3}{2}}{\alpha_1+\beta_1}\{(1-3A_r+6A_{,}^2-\qquad)\ (1+3A_v-\frac{9}{2}A_v^2-\qquad)-1\}\cos(\alpha+\beta)\right.$$

$$\left.+\frac{\frac{3}{2}}{\alpha_1-\beta_1}\{(1-3A_{,}+6A_{,}^2-\qquad)\ (1-3A_v-\frac{9}{2}A_v^2-\qquad)-1\}\cos(\alpha-\beta)\right\}$$

$$+R^{a}_{42}\left\{\frac{2}{\alpha_1}\cos\alpha+\frac{1}{\alpha_1+\beta_1}\{(1-4A_{,}+\qquad\qquad)\ (1+2A_v-\qquad\qquad)-1\}\cos(\alpha+\beta)\right.$$

$$\left.+\frac{1}{\alpha_1-\beta_1}\{(1-4A_{,}+\qquad\qquad)\ (1-2A_v-\qquad\qquad)-1\}\cos(\alpha-\beta)\right\}$$

$$+R^{a}_{44}\left\{\frac{4}{\alpha_1}\cos\alpha+\frac{2}{\alpha_1+\beta_1}\{(1-4A_r+\qquad\qquad)\ (1-4A_v-\qquad\qquad)-1\}\cos(\alpha+\beta)\right.$$

$$\left.+\frac{2}{\alpha_1-\beta_1}\{(1-4A_{,}+\qquad\qquad)\ (1-4A_v-\qquad\qquad)-1\}\cos(\alpha-\beta)\right\}$$

$$+R^{a}_{,1}\frac{1}{\alpha_1}\cos\alpha\qquad\qquad+R^{a}_{,3}\frac{3}{\alpha_1}\cos\alpha\qquad\qquad+R^{a}_{55}\frac{5}{\alpha_1}\cos\alpha\qquad\text{(J)}$$

$$+Z^{\alpha}_{21}\Big\{\qquad +\frac{\frac{1}{2}}{\alpha_1'+\beta_1'}\{A_z\,(1-2A_{,}+\qquad)\,(1+A_v-\qquad)\}\cos\,(\alpha'+\beta')$$

$$+\frac{\frac{1}{2}}{\alpha_1'+\beta_1'}\{A_z\,(1-2A_{,}+\qquad.\;)\,(1-A_v-\qquad)\}\cos\,(\alpha'-\beta')\Big\}$$

$$+Z^{\alpha}_{32}\Big\{\qquad +\frac{1}{\alpha_1'+\beta_1'}\{A_z\,(1-\quad..\qquad)\,(1+\qquad)\}\cos\,(\alpha'+\beta')$$

$$+\frac{1}{\alpha_1'-\beta_1'}\{A_z\,(1-\quad.\qquad)\,(1+\quad.\qquad)\}\cos\,(\alpha'-\beta')\Big\}$$

$$+Z^{\alpha}_{11}\Big\{\qquad +\frac{\frac{1}{2}}{\alpha_1''+\beta_1''}\{A_z^2\,(1-\qquad)\,(1+\qquad)\}\cos\,(\alpha''+\beta'')$$

$$+\frac{\frac{1}{2}}{\alpha_1''-\beta_1''}\{A_z^2\,(1-\qquad)\,(1-\qquad)\}\cos\,(\alpha''-\beta'')\Big\}$$

$$+\Big\{\frac{1}{2}\,U^2\,\{(1+A_{,})^2+U^2\,(G+A_{\psi})^2\,(1+A_{r})^4-U^4\,(G+A_{\psi})^4\,(1+A_{,})^6+U^6\,(G+A_{\psi})^6\,(1+A_{,})^8-\qquad\Big\}$$

$$R^{\alpha}_{22}\Big\{\frac{2}{\alpha_1}\,[\cos\,(\alpha+\omega)+\cos\,(\alpha-\omega)]$$

$$+\frac{1}{\alpha_1+\beta_1}\{(1-2A_{,}+3A_{,}^2-4A_{r}^3\qquad)\,(1+2A_v-2A_v^2-\frac{4}{3}A_v^3\qquad)-1\}[\cos\,(\alpha+\beta+\omega)+\cos\,(\alpha+\beta-\omega)]$$

$$+\frac{1}{\alpha_1-\beta_1}\{(1-2A_{,}+3A_{,}^2-4A_{,}^3+\qquad)\,(1-2A_{\iota}+2A_{\iota}^2-\frac{4}{3}A_{\iota}^3-\qquad)-1\}[\cos\,(\alpha-\beta+\omega)+\cos\,(\alpha-\beta-\omega)]\Big\}$$

$$+R^{a}_{31}\left\{\frac{1}{\alpha_1}\left[\cos(\alpha+\omega)+\cos(\alpha-\omega)\right]\right.$$

$$+\frac{\frac{1}{2}}{\alpha_1+\beta_1}\{(1-3A_r+6A_r^2-\ldots \qquad)(1+A_\upsilon-\tfrac{1}{2}A_\upsilon^2-\ldots \qquad)-1\}\left[\cos(\alpha+\beta+\omega)+\cos(\alpha+\beta-\omega)\right]$$

$$\left.+\frac{\frac{1}{2}}{\alpha_1-\beta_1}\{(1-3A_r+6A_r^2- \qquad)(1-A_\iota-\tfrac{1}{2}A_\iota^2- \qquad)-1\}\left[\cos(\alpha-\beta+\omega)+\cos(\alpha-\beta-\omega)\right]\right\}$$

$$+R^{a}_{3,3}\left\{\frac{3}{\alpha_1}\left[\cos(\alpha+\omega)+\cos(\alpha-\omega)\right]\right.$$

$$+\frac{\frac{3}{2}}{\alpha_1+\beta_1}\{(1-3A_r+6A_r^2- \qquad)(1+3A_\upsilon-\tfrac{9}{2}A_\upsilon^2- \qquad)-1\}\left[\cos(\alpha+\beta+\omega)+\cos(\alpha+\beta-\omega)\right]$$

$$\left.+\frac{\frac{3}{2}}{\alpha_1-\beta_1}\{(1-3A_r+6A_r^2- \qquad)(1-3A_\iota-\tfrac{9}{2}A_\upsilon^2- \qquad)-1\}\left[\cos(\alpha-\beta+\omega)+\cos(\alpha-\beta-\omega)\right]\right\}$$

$$+R^{a}_{42}\left\{\frac{2}{\alpha_1}\left[\cos(\alpha+\omega)+\cos(\alpha-\omega)\right]\right.$$

$$+\frac{1}{\alpha_1+\beta_1}\{(1-4A_r+ \qquad)(1+2A_\iota- \qquad)-1\}\left[\cos(\alpha+\beta+\omega)+\cos(\alpha+\beta-\omega)\right]$$

$$\left.+\frac{1}{\alpha_1-\beta_1}\{(1-4A_r+ \qquad)(1-2A_\iota- \qquad)-1\}\left[\cos(\alpha-\beta+\omega)+\cos(\alpha-\beta-\omega)\right]\right\}$$

$$+R^{a}_{44}\left\{\frac{4}{\alpha_1}\left[\cos(\alpha+\omega)+\cos(\alpha-\omega)\right]\right.$$

$$+\frac{1}{\alpha_1+\beta_1}\{(1-4A_r+ \qquad)(1-4A_\iota- \qquad)-1\}\left[\cos(\alpha+\beta+\omega)+\cos(\alpha+\beta-\omega)\right]$$

$$\left.+\frac{1}{\alpha_1-\beta_1}\{(1-4A_r+ \qquad)(1-4A_\upsilon- \qquad)-1\}\left[\cos(\alpha-\beta+\omega)+\cos(\alpha-\beta-\omega)\right]\right\}$$

$$+R^{a}_{51}\left\{\frac{1}{a_1}\left[\cos(a+\omega)+\cos(a-\omega)\right]\right\} \qquad +R^{a}_{53}\left\{\frac{3}{a_1}\left[\cos(a+\omega)+\cos(a-\omega)\right]\right\} \qquad +R^{a}_{55}\left\{\frac{5}{a_1}\left[\cos(a+\omega)+\cos(a-\omega)\right]\right\}$$

$$+Z^{a}_{21}\left\{\frac{\frac{1}{2}}{a_1{}'+\beta_1{}'}\{A_z(1-2A,+ \qquad)(1+A- \qquad)\}\left[\cos(a'+\beta'+\omega)+\cos(a'+\beta'-\omega) \qquad \right]\right.$$

$$\left.+\frac{\frac{1}{2}}{a_1{}'-\beta_1{}'}\{A_z(1-2A,+ \qquad)(1-A- \qquad)\}\left[\cos(a'-\beta'+\omega)+\cos(a'-\beta'-\omega) \qquad \right]\right\}$$

$$+Z^{a}_{32}\left\{\frac{1}{a_1{}'+\beta_1{}'}\{A_z(1- \qquad)(1+ \qquad)\}\left[\cos(a'+\beta'+\omega)+\cos(a'+\beta'-\omega) \qquad \right]\right.$$

$$\left.+\frac{1}{a_1{}'-\beta_1{}'}\{A_z(1- \qquad)(1- \qquad)\}\left[\cos(a'-\beta'+\omega)+\cos(a'-\beta'-\omega) \qquad \right]\right\}$$

$$+Z^{a}_{11}\left\{\frac{\frac{1}{2}}{a_1{}''+\beta_1{}''}\{A_z^2(1- \qquad)(1+ \qquad)\}\left[\cos(a''+\beta''+\omega)+\cos(a''+\beta''-\omega)\right]\right.$$

$$\left.+\frac{\frac{1}{2}}{a_1{}''-\beta_1{}''}\{A_z^2(1- \qquad)(1- \qquad)\}\left[\cos(a''-\beta''+\omega)+\cos(a''-\beta''-\omega)\right]\right\}\Bigg\}$$

$$+$$

It only remains to substitute in turn for the general coefficient and angles involved in the preceding expression their proper particular values, and the complete solution of this portion of the differential equations will be obtained These equations, when thus expanded in full, may seem very lengthy, but they really involve many apparently complex functions which are common to many portions, and which only require to be computed once for all For this reason they involve less work than even in Pontécoulant's Lunar Theory, which is carried only to the fifth order of small quantities

§ 8

Assume that it is possible to express every argument involved in the different functions which constitute the various differential equations as linear functions of the four angles θ, β, α, μ, increasing uniformly with the time. Then, by giving proper integral values, positive or negative, and including zero, to the four coefficients i, j, k, l, every argument may be included under the common form

$$\{i\theta+j\beta+k\alpha+l\mu\}$$

By properly defining these four variable angles this assumption will be rendered permissible. Further, suppose it to be possible to express the coefficients of these arguments as functions of the five small quantities, m, e, ε, η, b, to be hereafter defined, and assume that the lowest order in which these quantities are involved in these coefficients is known and expressed by s. Then all these arguments may be expressed by the general symbol

$$\mathrm{P}_a^{(s)}$$

Let P be a general function of the form

$$\mathrm{P}=\Sigma \mathrm{P}_a^{(s)} \begin{matrix}\sin\\ \cos\end{matrix}\left\{i\theta+j\beta+k\alpha+l\mu\right\}, \tag{1}$$

the summation being made to include every argument which enters into any of the functions which are comprised in the differential equations. Then this series denoted by P may be regarded as being the general function of which the different functions entering into the various differential equations are particular cases. By giving proper values to the coefficient $\mathrm{P}_a^{(s)}$, including the value zero, this general expression P may be made to represent any particular function or sum of any particular functions that is involved in the differential equations.

Let s be the order of the coefficient of any particular term in the function R^o, the argument of this term being supposed to be denoted by Θ. The coefficient of the corresponding term in $\left[r_0\delta\frac{1}{r}\right]$, that is the term with the same argument Θ, will be of the order s, $(s-1)$, or $(s-2)$. If the first, distinguish the term in the general function P, by writing the coefficient unaltered as $P_a^{(s)}$. If it be of the order $(s-1)$, write the coefficient $P_a^{(s)_1}$ or $P_a^{(s_1)}$ If it be of the order $(s-2)$, write the coefficient as $P_a^{(s)_2}$ or $P_a^{(s_2)}$. Considering next the corresponding term in (δv), its order will be also s, $(s-1)$, or $(s-2)$ Distinguish these three cases in the general function P on the same principle as before, writing their coefficient as $P_a^{(s)}$, $P_a^{(s')}$ or $P_a^{(s)'}$, and $P_a^{(s'')}$ or $P_a^{(s)''}$ Thus a coefficient which is of the order $(s-1)$ in $\left[r_o\delta\frac{1}{r}\right]$ and of the order $(s-2)$ in the function (δv) will be denoted by $P_a^{(s)_1''}$ or $P_a^{(s_1'')}$.

With these conditions fulfilled form the product P × P, and distinguish between the terms which arise from the addition of two arguments from those which arise from the subtraction of two arguments by prefixing the symbol $(+)$ and $(-)$ respectively. Then

$$(P)^2 = (\Sigma P_a^{(s)} \cos\{i\theta+j\beta+k\alpha+l\mu\}) \times (\Sigma P_a^s \cos\{i\theta+j\beta+k\alpha+l\mu\})$$

$$= \frac{1}{2}\,\Sigma\,\Sigma\,P_{a_1}^{(s)} P_{a_2}^{(s)} \left(\cos\{(i_1+i_2)\,\theta+(j_1+j_2)\,\beta+(k_1+k_2)\,\alpha+(l_1+l_2)\mu\}\right.$$
$$\left.+\cos\{(i_1-i_2)\,\theta+(j_1-j_2)\,\beta+(k_1-k_2)\,\alpha+(l_1-l_2)\,\mu\}\right),$$

the coefficients being, to save confusion, distinguished by suffixes This product will consist of a series of arguments of exactly the same form as P, and practically of almost the same series identically Consider any one particular term in this product $(P)^2$ with the argument

$$\{(i)\,\theta+(j)\,\beta+(k)\,\alpha+(l)\mu\}$$

Then this term may be written as

$$\frac{1}{2}\,\Sigma\{(+)\,P_{a_1}^{(s)}\,P_{a_2}^{(s)}+(-)\,P_{a}^{(s)}\,P_{a}^{(s)}\}\cos\{(i)\,\theta+(j)\,\beta+(k)\,\alpha+l\,(\mu)\} \qquad (2)$$

The terms involved in this expression are supposed to be

$$\begin{aligned}
&P_{a_1}^{(s)} \cos\{i_1\theta+j_1\beta+k_1\alpha+l_1\mu\},\\
&P_{a_2}^{(s)} \cos\{i_2\theta+j_2\beta+k_2\alpha+l_2\mu\},\\
&P_{a}^{(s)} \cos\{i'\theta+j'\beta+k'\alpha+l'\mu\}, \qquad (3)\\
&P_{a''}^{(s)} \cos\{i''\theta+j''\beta+k''\alpha+l''\mu\}
\end{aligned}$$

Then in the expression for $(P)^2$ these quantities are to take every value which occurs in P within the limiting conditions that $(s)+(\varsigma)$ does not exceed a certain fixed value, and that

$$\begin{array}{llll} (i_1+i_2)=(i), & (j_1+j_2)=(j), & (h_1+h_2)=(h), & (\zeta_1+\zeta_2)=(\zeta), \\ (i'-i'')=(i), & (j'-j'')=(j), & (h'-h'')=(h), & (\zeta'-\zeta'')=(\zeta) \end{array} \qquad (4)$$

When this product is properly formed the coefficient of any argument in the product of two series of cosines, such as R^o and $\left(r_o\delta\frac{1}{r}\right)$, can be written down at once by putting for the general expression $P^{(s)}_{a_1}$, $P^{(s)}_{a_-}$ &c &c the proper coefficients $R^{(s)}_{o_1}$ &c and $A^{(s)}_{ra_-}$ &c &c.

From the four trigonometrical expressions

$$\begin{aligned} 2B_1\cos\phi_1\ B_2\cos\phi_2 &= B_1B_2\cos(\phi_1-\phi_2)+B_1B_2\cos(\phi_1+\phi_2), \\ 2B_1\sin\phi_1\ B_2\sin\phi_2 &= B_1B_2\cos(\phi_1-\phi_2)-B_1B_2\cos(\phi_1+\phi_2), \\ 2B_1\cos\phi_1\ B_2\sin\phi_2 &= -B_1B_2\sin(\phi_1-\phi_2)+B_1B_2\sin(\phi_1+\phi_2), \\ 2B_1\sin\phi_1\ B_2\cos\phi_2 &= B_1B_2\sin(\phi_1-\phi_2)+B_1B_2\sin(\phi_1+\phi_2), \end{aligned}$$

it is evident that, by changing the sign of the terms resulting from the addition of two arguments, or those to which the symbol $(+)$ is prefixed, the expression for $(P)^2$ will yield the expression for the product of two series of sines Similarly, changing the cosines of the series into sines and the expression will yield the result for the product of a series of sines and a series of cosines, the apparent drawback of being obliged to retain the expression in the form of the last trigonometrical development being readily obviated by a simple artifice

It is only necessary therefore in the general expression for $(P)^2$ to replace the coefficients $P^{(s)}_{a_1}$ &c by their special values in the functions R^o, Z^o, &c &c to be able to write down all the products which, when united, form the complete development of the differential equations

It is more convenient to form two separate special cases of this general function, one consisting of arguments either independent of β or involving an even multiple of β and the other depending solely on arguments involving an uneven multiple of β By this means the length of the function denoted by $(P)^2$ may be much shortened The second class of terms is only wanted for the perturbations in latitude Finally, if this process is adopted additional functions will be wanted expressing the product of these two smaller functions by shorter series depending on arguments involving uneven multiples of β Though in practice this modification is much shorter, in theory it is simpler to suppose that the function P is complete

§ 9

From the expression for the product $(P)^2$ obtained by multiplying the general function P by itself, the different powers of $[r_0\delta\frac{1}{r}]$ and of $[\delta v]$ and of their products can be readily formed In conformity with the notation already established, suppose the coefficients of any particular term whose argument is β to be denoted in the following functions in the following manner:—

$$\left[r_0\delta\frac{1}{r}\right]=A_{r_b},\qquad \left[r_0\delta\frac{1}{r}\right]^n=A^n_{r_b},\qquad [\delta v]=A_{v_b},\qquad [\delta v]^m=A^m_{v_b},$$
$$\left[r_0\delta\frac{1}{r}\right]^n[\delta v]^m=A^n_{r_b}A^m_{v_b} \tag{1}$$

Returning to equations 6 and 7 (§ 6), let

$$[\overset{+}{A}_{\lambda,j}]_a=\frac{1}{2}\Big\{\Big(1-\lambda A_{r_b}+(\lambda+\frac{1}{2}\lambda\,[\lambda-1])A^2_{r_b}-(\lambda+\lambda\,[\lambda-1]+\frac{1}{6}\lambda\,[\lambda-1]\,[\lambda-2])\,A^3_{r_b}+\qquad\Big)$$
$$\Big(1+jA_{v_b}-\frac{1}{2}j^2A^2_{v_b}-\frac{1}{6}j^3A^3_{v_b}+\qquad\Big)-1\Big\}$$
$$\tag{2}$$
$$[\overline{A}_{\lambda,j}]_a=\frac{1}{2}\Big\{\Big(1-\lambda A_{r_b}+(\lambda+\frac{1}{2}\lambda\,[\lambda-1])A^2_{r_b}-(\lambda+\lambda\,[\lambda-1]+\frac{1}{6}\lambda\,[\lambda-1]\,[\lambda-2])\,A^3_{r_b}+\qquad\Big)$$
$$\Big(1-jA_{v_b}-\frac{1}{2}j^2A^2_{v_b}+\frac{1}{6}j^3A^3_{v_b}+\qquad\Big)-1\Big\},$$

and further, to secure brevity, for any argument Θ, put

$$f_\Theta=[\lambda+2]+2j\frac{m}{\Theta_1},\qquad f_{(\Theta+\gamma)}=-m\frac{(\lambda+1)\,c'-jc''}{\Theta_1+\gamma_1},\qquad f_{(\Theta-\gamma)}=m\frac{(\lambda+1)\,c'+jc''}{\Theta_1-\gamma_1} \tag{3}$$

Then the value of Q′ (Eq 12, § 6) may be written

$$\begin{aligned} Q' = \Sigma\,[R^o_{k,j}]_a \Big\{ &\{f_a \cos a + f_{(a+\gamma)} \cos (a+\gamma) + f_{(a-\gamma)} \cos (a-\gamma)\} \\ &+ [\overset{+}{A}_{k,j}]_b \{f_{(a+\beta)} \cos (a+\beta) + f_{(a+\beta+\gamma)} \cos (a+\beta+\gamma) + f_{(a+\beta-\gamma)} \cos (a+\beta-\gamma)\} \\ &+ [\overset{-}{A}_{k,j}]_b \{f_{(a-\beta)} \cos (a-\beta) + f_{(a-\beta+\gamma)} \cos (a-\beta+\gamma) + f_{(a-\beta-\gamma)} \cos (a-\beta-\gamma)\} \Big\} \end{aligned} \qquad (4)$$

Consider any particular term in Q′ whose argument is represented by

$$\{(i)\,\theta + (j)\,\beta + (k)\,a + (l)\,\mu\} = (a) \qquad (5)$$

Suppose the coefficient of this term in R^o is $[R^o_{k,j}]_{(a)}$ and let two representative terms in R^o be

$$[R^o_{k,j}]_{a_1} \cos \{i_1\theta + j_1\beta + k_1 a + l_1\mu\} = [R^o_{k,j}]_{a_1} \cos [a_1], \qquad (6)$$

$$[R^o_{k,j}]_{a'} \cos \{i'\theta + j'\beta + k'a + l'\mu\} = [R^o_{k,j}]_{a'} \cos [a'] \qquad (7)$$

In a similar manner let two representative values of the angle β be

$$\{i_2\theta + j_2\beta + k_2 a + l_2\mu\} = \beta_2, \qquad (8)$$

$$\{i''\theta + j''\beta + k''a + l''\mu\} = \beta'', \qquad (9)$$

their coefficients being distinguished by the suffixes b_2 and b'' respectively Then these representative terms give in the portion of Q′ which is independent of the angle γ the term with the argument (a)

$$\frac{1}{2}\{2\,[R^o_{k,j}]_{(a)} f_{(a)} + [R^o_{k,j}]_{a_1} [\overset{+}{A}_{k,j}]_{b_2} f_{(a)} + [R^o_{k,j}]_{a'} [\overset{-}{A}_{k,j}]_{b''}\} \cos [(a)], \qquad (10)$$

with the conditions

$$\begin{aligned} a_1 + \beta_2 = (a) \quad \text{or} \quad &\{(i_1+i_2)\,\theta + (j_1+j_2)\,\beta + (k_1+k_2)\,a + (l_1+l_2)\,\mu\} \\ &= \{(i)\,\theta + (j)\,\beta + (k)\,a + (l)\,\mu\}, \\ a' + \beta'' = (a) \quad \text{or} \quad &\{(i'-i'')\,\theta + (j'-j'')\,\beta + (k'-k'')\,a + (l'-l'')\,\mu\} \\ &= \{(i)\,\theta + (j)\,\beta + (k)\,a + (l)\,\mu\}, \end{aligned} \qquad (11)$$

where the angles θ, β, α, μ being supposed independent, their coefficients must be identical for the two values to be equal, or $(i_1+i_2) = (i)$, $(j_1+j_2) = (j)$,

&c &c Summing up every pair of angles satisfying these conditions, and putting $Q''_{(a)}$ for the portion of the coefficient independent of the function $\frac{1}{2}f_{(a)}$, or making

$$Q''_{(a)} = \Sigma\{[R''_{i,j}]_{(a)} + [R''_{i,j}]_{a_1}[\overset{+}{A}_{i,j}]_{b_2} + [R''_{k,j}]_{a'}[\bar{A}_{k,j}]_{b'}\}, \tag{12}$$

and the portion of the coefficient of the argument (a) in the function Q′ which is independent of γ becomes

$$\frac{1}{2}f_{(a)}Q'_{(a)} = \frac{1}{2}\Sigma f_{(a)}\{[R''_{i,j}]_{(a)} + [R''_{i,j}]_{a_1}[\overset{+}{A}_{k,j}]_{b} + [R''_{i,j}]_{a'}[\bar{A}''_{i,j}]_{b}\}, \tag{13}$$

the summation extending merely to the pairs of arguments α_1, β_2 and α', β''

The general expression for $(P)^2$ is exactly analogous in form to the above, and is coextensive, so that it gives every possible combination of $\alpha_1\ \beta_2$ or $a_1\ b_2$ which fulfil the necessary conditions Every term therefore in the coefficient of the argument (a) in the function $(P)^2$ which is of the form

$$\{(+)P_{a}P_{a_2} + (-)\ P_{a'}P_{a''}\} \tag{14}$$

will have a corresponding term of the form

$$\{[R''_{k,j}]_{a_1}[\overset{+}{A}_{i,j}]_{b_2} + [R_{i,j}]_{a'}[\bar{A}_{i,j}]_{b''}\} \tag{15}$$

in the function $Q''_{(a)}$ These terms can be written off at once from the expression for $(P)^2$

Considering the portion depending on the angle γ, which represents a series of angles of the same form Let this series be denoted by

$$\gamma = \Sigma n\mu, \tag{16}$$

and extend the notation for the angles by making

$$a \pm n = \{i\theta + j\beta + ka + (l \pm n)\mu\} \tag{17}$$

Finally, when $\gamma = n\mu$ suppose

$$f_{(a\pm\gamma)} = f_{a\pm n} \tag{18}$$

Referring to (4), it is evident that the portion depending on the angle γ may be divided into two portions, those in which γ is added and those in which it is subtracted Considering the angle Θ, on the addition of γ it is to become (a), therefore Θ must be made equal to $(a)-\gamma$ Instead, therefore, of taking the angles α and β so that α, $(\alpha+\beta)$, and $(\alpha-\beta)$ are equal to (a), they must be taken so as to make these equal to $(a)-n$

By 12 therefore

$$Q'_{(a)-n}=\Sigma\{[R^{o}_{k,j}]_{(a)-n}+[R^{o}_{k,j}]_{a_1}\,[\overset{+}{A}_{i,j}]_{b_2}+[R^{o}_{i,j}]_{a'}\,[\bar{A}_{i,j}]_{b''}\}, \tag{19}$$

the terms distinguished by the suffixes a_1, b_2, a', b'' being now taken so as to satisfy the conditions

$$\alpha_1+\beta_2=(a)-n, \qquad\qquad \alpha'-\beta''=(a)-n$$

By combination with the angle $\gamma=n\mu$ each of the above terms gains the increment $n\mu$ and their argument becomes (a) Therefore the portion depending on the terms in Q' which add the increment γ to the argument is

$$\frac{1}{2}\Sigma\, f_{[(a)-n]+n}\;\{Q''_{(a)-n}\} \tag{20}$$

By simply changing the sign of n, the corresponding portion depending on the terms in Q' which lose the angle γ from their arguments will be found

The complete value of Q' will give therefore as the coefficient of the argument (a) in the function Q' the expression

$$Q_{(a)}=\frac{1}{2}\,f_{(a)}\;\{Q''_{(a)}\}+\frac{1}{2}\,\Sigma f_{[(a)-n]+n}\;\{Q''_{(a)-n}\}+\frac{1}{2}\,\Sigma f_{[(a)+n]-n}\;\{Q''_{(a)+n}\} \tag{21}$$

The summation extends merely to every integral value of n which it is necessary to consider. The functions $Q''_{(a)}$, $Q''_{(a)-n}$, $Q''_{(a)+n}$ are to be derived from Equations 12 and 19 by the aid of 14 and 15

The portions of Q (Eq 18, § 6) depending on the function Z are to be formed in exactly the same way, it being merely necessary to alter the notation by writing $[Z_{[k+1],j}]_a$ and $[A_{-}+A_{z}\overset{+}{A}_{[k+1],j}]_b$ for $[R^{o}_{k,j}]_a$ and $[\overset{+}{A}_{k,j}]_b$ respectively, and similarly for the other functions

By this means the complete development of Q may be made to depend entirely on the expression for $(P)^2$, it being only necessary to replace one symbol by another to obtain from the value of $(P)^2$ the complete value of the more complex function Q

In exactly the same manner as Q is developed, the complete value of the function $\frac{dR}{d\psi}$ can be obtained (Eq 31, § 6) In this case no terms depending on the angles typified by γ occur (Eq F), so that this portion of the work vanishes

Finally, the development of the differential equation to δv divides itself into two portions One in which the work is exactly of the same nature as developing Q, only that no terms depending on γ appear Secondly, a portion depending on the triple combination of α, β, and ω, and necessitating a double application of the function P This can be simplified, because, in forming the third powers of $\left(r_0 \delta \frac{1}{r}\right)$ and (δv) a result equivalent to the formation of $(P)^3$ is obtained By a slight additional labour the complete function of $(P)^3$ in the special case of the argument involving only even multiples of β, or else independent of β, can be formed This special form of $(P)^3$ will enable this double application of $(P)^2$ to be avoided and reduce the formation of this part of $\frac{d\delta v}{dt}$, depending on the three angles α, β, ω to exactly the same form as that depending on α, β alone

London, May 1877.

II. *Determination of the Solar Parallax from the Opposition of Mars*, 1877

By MAXWELL HALL, Esq

◆

INTRODUCTION.

OBSERVATIONS of *Mars* were made in Jamaica during the last opposition of the planet, in order to determine the Solar Parallax by means of the displacement of the planet in Right Ascension, when far east and far west of the meridian as seen at a single place

The small Observatory is situated about 5¼ miles south-east of Montego Bay, on a range of hills 1,800 feet above the sea-level, the buildings consist of a square transit room and a circular tower for the Equatoreal, the piers for the instruments are founded on solid rock, and the whole of the masonwork is compact and substantial

The instruments were made by Messrs Cooke & Sons, of York, and the mounting of the Equatoreal is very firm and massive The aperture of the object glass is only 4 inches, but the definition is very good, the transit eye-piece has five wires about 2′ 45″ apart, and a power of 120 was employed It is needless to refer to the usual appliances and means of adjustment, except, indeed, the long microscope for reading the declination circle from the observing seat, which was found to be particularly useful

The Transit-instrument has an aperture of 3 inches, it may easily be reversed, and it is provided with a very delicate hanging level The setting circle is adjusted by another very delicate spirit level, so as to indicate zenith distances, there are two verniers, diametrically opposite to one another, and furnished with microscopes By means of the verniers the limb of the circle is divided into parts containing 20″ of arc

As soon as the Transit-instrument and the Clock had been mounted, the setting circle was employed to obtain the approximate colatitude   Five zenith distances were observed on the evening of October 27, 1875, and five more were observed on the following evening, the axes of the instrument having been reversed in the meantime, in order to eliminate the index error of the circle by merely taking the mean of the ten results.   From these observations the colatitude was found to be $71^\circ\ 35'\ 8''\ 8$

In order to confirm this value, a second series was commenced on September 22, 1876, 28 observations were made on five evenings; the instrument was reversed every evening, and as many stars observed in the one position as in the other, the resulting colatitude was $71^\circ\ 35'\ 9''\ 4$

In February 1877 it became necessary to arrive at a definite conclusion regarding the colatitude, and on the evening of the 15th twelve observations gave $71^\circ\ 35'\ 9''\ 0$, which was so satisfactory that it seemed useless to continue the work, especially as the colatitude may be affected by local disturbance of gravitation

In order to obtain the most probable value of the colatitude from all the observations, we have

$$\begin{array}{rcr} '' & & '' \\ 10\times 8\ 8 & = & 88 \\ 28\times 9\ 4 & = & 263 \\ 12\times 9\ 0 & = & 108 \\ & & \overline{50)459} \\ & & \overline{\ \ 9\ 2}, \end{array}$$

so that the colatitude is $71^\circ\ 35'\ 9''\ 2$, nearly

Considering the Earth as a spheroid of revolution, and adopting Captain CLARKE's results (*Memoirs of the Royal Astronomical Society*, vol xxix), the angle of the vertical is $6'\ 59''\ 0$, and r is 0 9996641 in terms of the equatorial radius   But the elevation of the Observatory above the sea-level is 0 0000860, hence we must take r as 0 9997501, and log r as 9 9998914

The longitude of the Observatory has been found from transits of the Moon and Moon-culminating stars, and the tabular positions and motions of the Moon as given in the *Nautical Almanac*   The first limb has been observed

24 times, and the second limb 20 times, the approximate longitude deduced is $5^h\ 11^m\ 10^s$ west of Greenwich, with a probable error less than 1^s, but as it is my intention to make a few more observations, and to equalise the number of times the limbs are observed, the article on the "Longitude by means of Moon culminating Stars" has not yet been completed This is of no consequence at present, as only an approximate value of the longitude is required

The Clock is provided with a mercurial compensating pendulum and the dead-beat escapement It was an inexpensive instrument (costing only £35), for it was chiefly intended to adjust the Equatoreal In March, before the opposition, I cleaned the works, and attended carefully to the compensation, and as the daily change of rate was generally small, $0^s\ 5$ or so, I hoped that the clock would be sufficiently good for the observation of *Mars*. But herein I was completely mistaken, and must explain as fully as possible

At any given instant, let E be the Clock Error, R the Rate in one sidereal day, and $\frac{dR}{dt}$ the Acceleration, then if E_1 was the clock error at an instant preceding the given instant by the interval t_1, expressed in terms of a sidereal day,

$$E_1 = E - t_1 R + t_1^2 \left(\frac{1}{2}\frac{dR}{dt}\right)$$

Similarly if E_2 be the error at an instant following the given instant by the interval t_2, we have

$$E_2 = E + t_2 R + t_2^2 \left(\frac{1}{2}\frac{dR}{dt}\right).$$

Let

$$r_1 = \frac{E - E_1}{t_1},$$

$$r_2 = \frac{E_2 - E}{t_2},$$

so that r_1 and r_2 would each be the clock rate if uniform, then

$$\frac{1}{2}\frac{dR}{dt} = \frac{r_2 - r_1}{t_1 + t_2},$$

$$R = r_1 + t_1 \left(\frac{1}{2}\frac{dR}{dt}\right).$$

These were the equations employed to find R and $\frac{dR}{dt}$, assuming that $\frac{dR}{dt}$ was very small and nearly constant But in fact $\frac{dR}{dt}$ was the opposite in both respects, going through large changes in very small periods of time: for instance, an interval of 120 seconds between two stars is generally measured by $119^s 9$ and $120^s 1$ alternately, but often there is far greater irregularity, and differences of $0^s 2$, $0^s 3$, and $0^s 4$ will be found in Sec III between consecutive measures of such an interval

Consequently $\frac{dR}{dt}$, as found above, is merely the sum of all such irregularities during the 24 hours, and the fact that $\frac{dR}{dt}$ was small refers to the mathematical theory of probability, rather than to the quality of the clock

This was not known until the observations were in progress, of course small discrepancies had always been observed with the Transit-instrument and the clock stars; but the errors of adjustment are liable to change, and the errors of observation with a low power of 70 are large, so that the Transit-instrument had failed to detect this performance of the clock, moreover the intervals between the *Nautical Almanac* stars are generally about ten minutes, and during that time the clock goes through several changes.

The observations were commenced on the 4th of August, and were continued with but few interruptions up to September 17, when the weather broke up Indications of a cyclone sweeping the Gulf Stream were apparent on the 25th; it passed Jamaica to the south on the 27th, but the sky was not clear for some days afterwards, when it was considered inexpedient to resume the observations

The work is divided into four sections The first contains an article on the adjustment of the Equatoreal, the second an article on the reduction of the observations, the third contains the observations themselves, and the last the determination of the Solar Parallax in accordance with the previous sections

SECTION I

On the Adjustment of the Equatoreal

In the adjustment of the Equatoreal, correction or allowance has to be made for eight instrumental errors; and as refraction must also be considered at the same time, there are nine corrections to be made, or indeed ten, if we include the clock error Refraction requires our first consideration, as soon as we have explained our notation

The Hour-angle of a star, h, is measured on the hour circle from the meridian westwards through 24 hours to the meridian again, the Right Ascension, R A, is measured from the First Point of *Aries* along the celestial Equator in hours, minutes, and seconds of sidereal time, and the North Polar Distance, Δ, is measured on the declination circle in preference to the Declination itself, in order to avoid the sign of the latter

If the telescope be directed to a star at its upper transit, with the declination circle towards the west, and if the star be followed in its diurnal course, the telescope will always be in the *direct* position. But if the declination circle be towards the east, and if the star be followed in the same manner, then the telescope will always be in the *reverse* position For the sake of distinction, the Hour-angle and the North Polar Distance are marked h' and Δ' when the telescope is in the reverse position

Let f'' be the Mean Refraction in seconds of arc for the apparent zenith distance of 45°, let $f = \frac{f''}{15}$, so that f is the same quantity expressed in seconds of Right Ascension; and let a similar notation be applied to all the other coefficients of the corrections Now the mean annual height of the barometer (unreduced) is $28^{\text{in}}\,20$, and the mean annual temperature of the air is 72° 0 F, hence, by Bessel's "Refraction Tables" (*Greenwich Appendix for* 1853), we have

$$f = \overset{s}{3}\;49, \qquad \log f = 0\;54304,$$

$$f'' = 5\overset{''}{2}\;38, \qquad \log f'' = 1\;71913$$

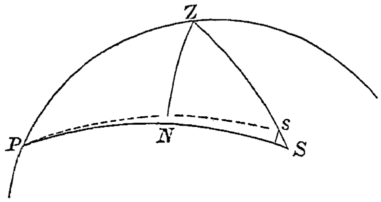
But these constants will require correction at times for variation in the barometer and thermometer; supposing that the readings of the barometer, B, are always unreduced, and that the mercury in the barometer has the same temperature as the mercury in the thermometer, T, exposed in the shade, we have

$$f = 3^{\mathrm{s}}49 + 0^{\mathrm{s}}12\ (\mathrm{B}-28^{\mathrm{in}}20) - 0^{\mathrm{s}}0075\ (\mathrm{T}-72^{\circ}0),$$

$$f'' = 52''38 + 1''86\ (\mathrm{B}-28^{\mathrm{in}}20) - 0''112\ (\mathrm{T}-72^{\circ}0)$$

Now if z be the apparent zenith distance of a star, the refraction in zenith distance is f'' tan z, unless the star is very near the horizon. the error is $+3''\ 1$ for the apparent zenith distance of 75°, and $+11''\ 5$ for the apparent zenith distance of 80°, so that the expression f'' tan z cannot be employed for zenith distances greater than 75°

In this figure we have



$\mathrm{PZ} = \gamma$, the colatitude,
$\mathrm{PS} = \Delta$,
$\mathrm{ZS} = z$, nearly,
$\angle \mathrm{ZPS} = h$,

and if ZN be drawn perpendicular to PS,

$$\sin \mathrm{ZN} = \sin \gamma \sin h,$$
$$\tan \mathrm{PN} = \tan \gamma \cos h$$

Now, suppose that a star is raised from S to s by refraction, then

$$\mathrm{S}s = f'' \tan z,$$

and

$$\text{Refraction in } h = -\frac{f \tan z \sin \mathrm{S}}{\sin \Delta},$$

$$\text{Refraction in } \Delta = -f'' \tan z \cos \mathrm{S},$$

where S is the angle ZSP

But

$$\frac{\sin \mathrm{S}}{\sin h} = \frac{\sin \gamma}{\sin z},$$

therefore

$$\sin z \sin \mathrm{S} = \sin \gamma \sin h,$$

or

$$\sin z \sin \mathrm{S} = \sin \mathrm{ZN}$$

Again

$$\cos z = \cos \mathrm{ZN} \cos \mathrm{SN},$$

or

$$\cos z = \cos \mathrm{ZN} \cos (\Delta - \mathrm{PN}),$$

therefore

$$\tan z \sin \mathrm{S} = \frac{\tan \mathrm{ZN}}{\cos (\Delta - \mathrm{PN})},$$

and as

$$\tan \quad \cos \mathrm{S} = \tan (\Delta - \mathrm{PN}),$$

we have

$$\text{Refraction in } h = -\frac{f \tan \mathrm{ZN}}{\sin \Delta \cos (\Delta - \mathrm{PN})},$$

$$\text{Refraction in } \Delta = -f'' \tan (\Delta - \mathrm{PN})$$

Hence, on account of refraction, we must apply a correction of

$$-\frac{f \tan \mathrm{ZN}}{\sin \Delta \cos (\Delta - \mathrm{PN})}$$

to the observed clock time of transit of a star across the wires in the field of view, and a correction of

$$+f'' \tan (\Delta - \mathrm{PN})$$

to the observed North Polar Distance

Let d'' be the index error for North Polar Distances, so that $\Delta - d''$ is the corrected reading when the instrument is direct, and $\Delta' + d''$ when the instrument is reverse, then

$$d'' = \frac{\Delta - \Delta'}{2},$$

and it may be found from a star when near the meridian by taking readings in both positions of the instrument *

Let y'' be the elevation of the instrumental pole above the true pole of the sphere, and let v'' be the horizontal flexure of the tube of the telescope, in consequence of which the eye-end bends down so as to raise the wires slightly in the direction of the zenith, then, if NPD be the apparent North

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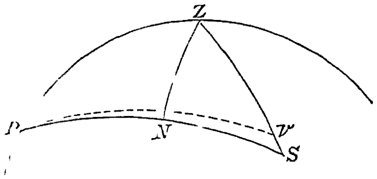
* There is a range of mountains due south of the Observatory at a distance of about ten miles, and as the definition is often very clear and distinct across the intervening valley, any mark near the south horizontal point may be used for the determination of d'', as well as for another important error discussed afterwards

Polar Distance of a star when it passes the meridian, we have

$$\text{NPD} = \Delta - d'' + f'' \tan(\Delta - \gamma) + y'' - v'' \sin(\Delta - \gamma),$$

and then y'' and v'' may be found from two stars which pass the meridian, one to the north and the other to the south of the zenith, and, supposing that either one or both stars are observed in opposite positions of the telescope, d'' can be obtained at the same time.

We now require general expressions for the effects of v''. Suppose that the wires are raised from S to v by flexure, so that



$$\text{S}v = v'' \sin z,$$

then

$$+\frac{v \sin z \sin \text{S}}{\sin \Delta}$$

is the correction to be applied to the observed clock time of transit, and

$$-v'' \sin z \cos \text{S}$$

is the correction to be applied to the observed North Polar Distance

But

$$\sin \text{ZN} = \sin z \sin \text{S},$$

hence the first correction is

$$+\frac{v \sin \text{ZN}}{\sin \Delta}$$

Again,

$$\cos \text{S} = \tan(\Delta - \text{PN}) \cot z,$$

therefore

$$\sin z \cos \text{S} = \tan(\Delta - \text{PN}) \cos z,$$

or

$$\sin z \cos \text{S} = \tan(\Delta - \text{PN}) \cos(\Delta - \text{PN}) \cos \text{ZN},$$

or again

$$\sin z \cos \text{S} = \sin(\Delta - \text{PN}) \cos \text{ZN},$$

so that the correction to the observed North Polar Distance is

$$-v'' \sin(\Delta - \text{PN}) \cos \text{ZN}$$

Let x'' be the deviation of the instrumental pole to the east of the true pole of the sphere; then, if a star be observed six sidereal hours after the upper transit, we have

$$\text{NPD} = \Delta - d'' + f'' \tan \Delta - x'' - v'' \sin \Delta \cos \gamma,$$

and

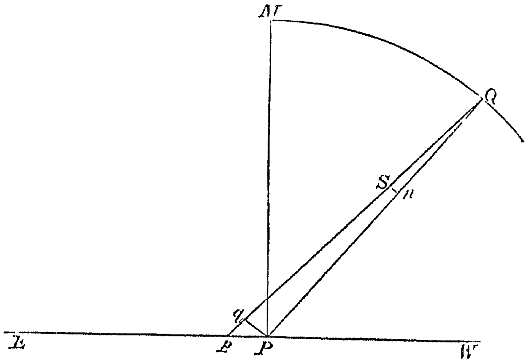
$$\text{NPD} = \Delta' + d'' + f'' \tan \Delta + x'' - v'' \sin \Delta \cos \gamma$$

if observed six hours before the upper transit, and thus x'' may be found by observing a star whose apparent positions are given in the *Nautical Almanac*, when six hours from the meridian

It will be convenient to determine these four errors d'', v'', x'', and y'' on the same evening, because d'' involves what may be termed the collimation of the single wire in North Polar Distance, and is liable to considerable change

It is now necessary to determine the general effects of x'' and y'', and we shall consider each separately

In this projection of the sphere upon the plane of the Equator, let P be the true Pole, PM the meridian, and MQ an arc of the Equator Then, if p be the instrumental pole x'' to the east of P, the plane of collimation will be a great circle passing through p and cutting the Equator in some point Q join PQ, and draw Pq perpendicular to PQ Then, as MQ measures the true hour angle MPQ, if a star were to transit the plane of collimation at S, by drawing Sn perpendicular to PQ we see that the time the star takes to traverse the arc of the small circle Sn must be added to the clock time of transit on account of the deviation of the instrumental pole



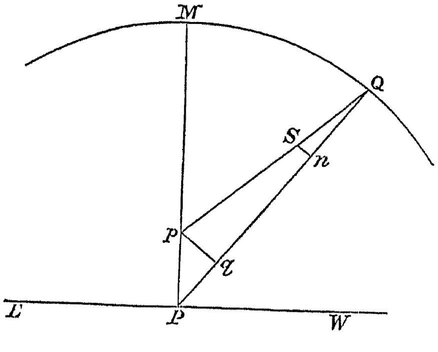
Now $Sn = Pq \cos \Delta$, and $Pq = x'' \cos h$, hence $\dfrac{x \cos \Delta \cos h}{\sin \Delta}$ must be added to the clock time of transit, and pq, or $x'' \sin h$, must be subtracted from the observed North Polar Distance

Similarly the effect of y'' may be found

$$Sn = pq \cos \Delta,$$

and

$$pq = y'' \sin h,$$

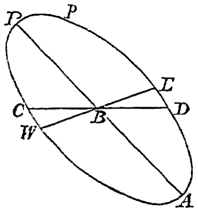


so that $\dfrac{y \cos \Delta \sin h}{\sin \Delta}$ must be added to the observed clock time of transit, and Pq, or $y'' \cos h$, must be added to the observed North Polar Distance.

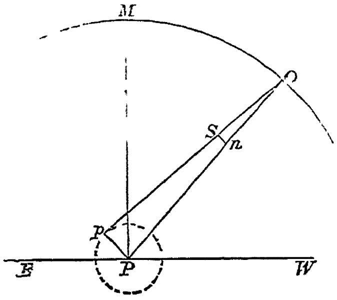
Let c be the error of collimation of the mean wire as in the case of the transit instrument, then $\frac{c}{\sin\ \Delta}$ must be added to the observed clock time when the instrument is direct and subtracted when reverse

Let e be the index error of the hour circle—this does not change sign—and $h-e$, or $h'-e$, will be the true reading of the circle

Let i'' be the error of inclination of the declination axis to the polar axis measured from the circle end of the former, so that $90^\circ+i''$ is the angle between these axes, and, in consequence, the instrumental pole will be displaced on the six-hour circle i'' from the true pole, and on the opposite side to the circle end



Thus, if AB be the polar axis of the instrument, EBW the horizontal line passing through the east and west points, CBD the declination axis, and C the circle end, then the angle CBW $= i''$ measured on the plane of the six-hour circle, and p, the instrumental pole, will be situated at a distance i'' from P



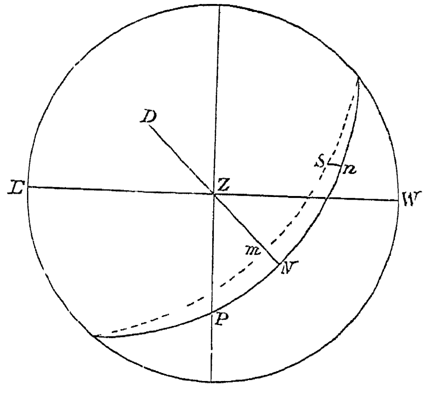
Now, if the declination-axis be turned round the polar axis, p will describe a small circle round P whose radius is i'', the plane of collimation will describe a great circle passing through p, and, as before, $\frac{i\cos\Delta}{\sin\Delta}$ must be added to the observed clock time of transit of any star whose North Polar Distance is Δ

This is for the *direct* position of the instrument, in the reverse position C is on the opposite side of P, and then $\frac{i\cos\Delta}{\sin\ \Delta}$ must be subtracted from the clock time of transit Of course this error does not affect North Polar Distances

The last error for consideration is the flexure of the declination-axis, u, or rather of that half of it to which the telescope is attached This flexure will always be directed from the zenith in a vertical plane, and it will vary in amount as the sine of the inclination of the axis to the vertical

When the instrument is direct, and the declination-axis level, the effect of u is to make the plane of collimation describe a great circle passing u'' to the east of the zenith, so that in the meridian $\frac{u \cos (\Delta - \gamma)}{\sin \Delta}$ must be added to the time of transit for the direct position and subtracted for the reverse We now proceed to find a general expression

In this projection of the sphere upon the horizontal plane, let DZN be the projection of the arc of 90° between the declination-axis DB and the plane of collimation, where DZN is of course perpendicular to the trace of that plane, PNn, and, in consequence of the downward flexure of D, let the plane of collimation be raised to the dotted line

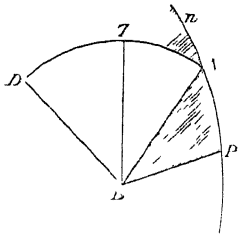


Now

$$\begin{aligned} Nm &= u'' \sin (\text{inclination of DB to vertical}) \\ &= u'' \cos ZN, \end{aligned}$$

and

$$\begin{aligned} Sn &= Nm \cos (\Delta - PN), \\ &= u'' \cos ZN \cos (\Delta - PN), \\ &= u'' \cos \quad, \end{aligned}$$



but we shall retain the former expression because ZN and PN have been already used for f and v

Hence

$$\frac{u \cos ZN \cos (\Delta - PN)}{\sin \Delta}$$

must be added to or subtracted from the clock time of transit according as the instrument is direct or reverse

Collecting our expressions,

RA = App Right Ascension } of a star
NPD = App North Polar Distance } of a star
T = Clock time of transit across the mean wire
E = Clock error

h = Hour-circle reading
Δ = North Polar Distance reading
γ = Colatitude, $71^\circ\ 35'\ 9''$
$\sin \mathrm{ZN} = \sin\gamma \sin h$, $\log \sin\gamma = 9.97717$
$\tan \mathrm{PN} = \tan\gamma \cos h$, $\log \tan\gamma = 10.47765$
c = Collimation of mean wire
d'' = Index error for North Polar Distances
e = Index error of hour circle
f = Coefficient of refraction
i = Error of inclination of declination-axis
u = Horizontal flexure of declination-axis
v = Horizontal flexure of telescope tube
x = Deviation of polar axis eastwards
y = Elevation of polar axis

Then, for the direct position of the instrument,

$$\mathrm{RA} = \mathrm{T}-\mathrm{E}-(h-e)+\frac{1}{\sin\Delta}\left\{c-\frac{f\tan \mathrm{ZN}}{\cos(\Delta-\mathrm{PN})}+i\cos\Delta+u\cos \mathrm{ZN}\cos(\Delta-\mathrm{PN})\right.$$
$$\left.+v\sin \mathrm{ZN}+(x\cos h+y\sin h)\cos\Delta\right\},$$

$$\mathrm{NPD} = \Delta-d''+f''\tan(\Delta-\mathrm{PN})-v''\cos \mathrm{ZN}\sin(\Delta-\mathrm{PN})-x''\sin h+y''\cos h$$

And for the reverse position of the instrument the signs of c, i, u, and d'' must all be changed

It still remains to find the errors c, e, i, and u by observation

Let the declination-axis be brought into the horizontal position by means of the spirit level, and let the corresponding reading of the hour circle be h_m, then the plane of collimation will nearly coincide with the meridian, and the equation becomes

$$\mathrm{RA} = \mathrm{T}-\mathrm{E}-(h_m-e)+\frac{1}{\sin\Delta}\{c+i\cos\Delta+u\cos(\Delta-\gamma)+x\cos\Delta\}$$

But as the plane of collimation passes through the zenith, if the transit of a zenith star be observed,

$$\mathrm{RA} = \mathrm{T}-\mathrm{E}+\frac{c}{\sin\gamma},$$

and

$$h_m-e = \frac{1}{\sin\gamma}(i\cos\gamma+u+x\cos\gamma)$$

The first equation gives us c, and e may be found by levelling the declination axis in the reverse position, when

$$h'_m - e = \frac{1}{\sin\gamma}(-\iota\cos\gamma - u + \iota\cos\gamma),$$

so that

$$e = \frac{1}{2}(h_m + h'_m) - v\cot\gamma$$

In observing the transit of the star near the zenith, it may be convenient to observe it a little distance from the meridian, in this case the equation becomes

$$\mathrm{RA} = \mathrm{T} - \mathrm{E} - (h - h_m) + \frac{c}{\sin\gamma},$$

or

$$\mathrm{RA} = \mathrm{T} - \mathrm{E} - (h' - h'_m) - \frac{c}{\sin\gamma},$$

according as the instrument is direct or reverse

But as there may be some difficulty in bringing the declination axis into the horizontal position, the following method of obtaining h_m and h'_m will prove useful

Let h_{N} be the reading of the hour circle when the telescope is directed to the north point on the horizon, and when the centre of the bubble has been brought to the centre of the scale by means of the tangent screw which gives the instrument motion in R A , let h_{S} be the reading when the telescope is directed to the south point on the horizon, then $\frac{1}{2}(h_{\mathrm{N}} + h_{\mathrm{S}})$ will be the reading of the hour circle for that position of the spirit level The spirit level must now be reversed, or turned end for end, and the readings taken again, then the mean of these four readings will be the required reading of the hour circle when the declination axis is level, or

$$h_m = \frac{1}{4}\{h_{\mathrm{N}} + h_{\mathrm{S}} + h_{\mathrm{S}'} + h_{\mathrm{N}'}\},$$

and, by reversing the whole instrument, we have in a similar manner,

$$h'_m = \frac{1}{4}\{h'_{\mathrm{N}} + h'_{\mathrm{S}} + h'_{\mathrm{S}'} + h'_{\mathrm{N}'}\}$$

Now we have one equation between i and u, namely

$$i \cos \gamma + u = \frac{1}{2} (h_m - h'_m) \sin \gamma ,$$

and we require another in order to determine both i and u

The transit of a star upon or near the celestial Equator across the meridian would furnish such an equation, $\cos \Delta$ would vanish, and the value of u could be deduced, and then i found from the above

But it will be more convenient to employ a distant mark on the south horizon, let h_s be the reading of the hour circle when the mark is cut by the middle wire in the direct position of the instrument, and let h'_s be the reading in the reverse position; then, as Δ is $90° + \gamma$, it may easily be shown that

$$i = \frac{c}{\sin \gamma} - \frac{1}{2} (h_s + h'_s) \cot \gamma ,$$

whence i, and then u from the above

If these instrumental errors are carefully determined and the corrections properly applied, the Apparent Right Ascension and North Polar Distance of a star may be determined from observation with as much accuracy as the graduations of the two circles will permit—2^s in R A and $10''$ in N P.D

Let $\phi(\Delta)$ be the sum of those corrections in Right Ascension which are functions of Δ, so that

$$\mathrm{RA} = \mathrm{T} - \mathrm{E} - (h - e) + \phi(\Delta) ,$$

and let us now consider the differential effect of $\phi(\Delta)$ on the difference in Right Ascension of two stars whose transits are observed consecutively at any the same hour-angle, supposing the two stars to have nearly the same North Polar Distance The preceding star will be referred to by the suffix ($_a$), and the following star by the suffix ($_b$), so that $(\mathrm{RA})_b - (\mathrm{RA})_a$ and $\mathrm{T}_b - \mathrm{T}_a$ are both positive quantities

Remembering that h, ZN, and PN are the same for both stars, we have by subtraction

$$\begin{aligned}\phi(\Delta)_b - \phi(\Delta)_a = {} & -f \tan \mathrm{ZN} \left\{ \frac{1}{\sin \Delta_b \cos (\Delta_b - \mathrm{PN})} - \frac{1}{\sin \Delta_a \cos (\Delta_a - \mathrm{PN})} \right\} \\ & + (c + v \sin \mathrm{ZN}) \left(\frac{1}{\sin \Delta_b} - \frac{1}{\sin \Delta_a} \right) \\ & + u \cos \mathrm{ZN} \left\{ \frac{\cos (\Delta_b - \mathrm{PN})}{\sin \Delta_b} - \frac{\cos (\Delta_a - \mathrm{PN})}{\sin \Delta_a} \right\} \\ & + (i + x \cos h + y \sin h)(\cot \Delta - \cot \Delta_a)\end{aligned}$$

Now if Δ_a and Δ_b are expressed in minutes of arc, we must divide the difference $\Delta_b - \Delta_a$ by 3438 in order to express that difference in circular measure; and then we easily obtain

$$\begin{aligned}\phi(\Delta)_b - \phi(\Delta)_a = \frac{\Delta_b - \Delta_a}{3438 \sin^2 \Delta} \Big\{ & f \tan \mathrm{ZN} \frac{\cos(2\Delta - \mathrm{PN})}{\cos^2(\Delta - \mathrm{PN})} \\ & - (c + v \sin \mathrm{ZN}) \cos \Delta \\ & - u \cos \gamma \\ & - (i + x \cos h + y \sin h) \Big\},\end{aligned}$$

where Δ may have any approximate value to Δ_a and Δ_b.

As an example of the great use of this formula, we shall apply it to the observations of *Mars* and adjacent comparison stars at the Opposition in 1877.

The N.P.D. of the planet is between 101° and 103°, so that the values of $\cos \Delta$ are between -0.19 and -0.22; if therefore c be always kept as small as possible by constant adjustment, the term $c \cos \Delta$ within the large bracket may safely be neglected. Again v is always small, and $\sin \mathrm{ZN}$ less than unity, so that the term $v \sin \mathrm{ZN} \cos \Delta$ may also be neglected. The term $x \cos h$ is always positive, and provided that x is small, the effect of this term will finally disappear, as only the *difference* between the morning and evening differences of Right Ascension are required. Lastly, y must be so far reduced by instrumental correction that the term $y \sin h$ may be neglected.

If therefore we put

$$\mathrm{F} = \tan \mathrm{ZN} \frac{\cos(2\Delta - \mathrm{PN})}{\cos^2(\Delta - \mathrm{PN})},$$

we have

$$\phi(\Delta)_b - \phi(\Delta)_a = \frac{\Delta_b - \Delta_a}{3438 \sin^2 \Delta} \{f\mathrm{F} - (i + u \cos \gamma)\},$$

and mean values of f, i, and u may be employed if the climate and stability of the instrument will allow this further simplification.

SECTION II

On the Reduction of the Observations.

Let π'' be the Sun's equatorial horizontal parallax at the mean distance of the Earth from the Sun, let ρ be the distance of *Mars* from the Earth at any given time, expressed in terms of the mean distance of the Earth from the Sun, let r be the Earth's radius at the place of observation, in terms of the equatorial radius Then $\frac{\pi'' r}{\rho}$ will be the planet's horizontal parallax; and if Z be the planet's geocentric zenith distance, we have

$$\text{Parallax in Geocentric zenith distance} = \frac{\pi'' r \sin Z}{\rho},$$

and, as in the case of v'' (*see* page 58) it may easily be shown that if Γ be the geocentric colatitude,

$$\frac{\pi'' r \sin \Gamma \sin h}{15\, \rho \sin \Delta}$$

is the correction to be applied to the clock time of transit of the planet in order to obtain the Right Ascension referred to the centre of the Earth

Let

$$P = \frac{r \sin \Gamma \sin h}{15\, \rho \sin \Delta},$$

where

$$\log \frac{r \sin \Gamma}{15} = 8{\cdot}80127,$$

then the correction may be written π'' P, and we can now proceed to the reductions

Let $(\mathrm{RA})_a$ be the Apparent Right Ascension of the comparison star, let $(\mathrm{RA})_1$ be the Apparent Right Ascension of the preceding limb of *Mars*, and let a similar notation be applied to all other variable quantities; then, for the first run,

$$(\mathrm{RA})_a = \mathrm{T}_{a\,1} - \mathrm{E}_{a\,1} - (h_1 - e) + \phi\,(\Delta)_{a\,1},$$
$$(\mathrm{RA})_1 = \mathrm{T}_1 \quad - \mathrm{E}_1 \quad - (h_1 - e) + \phi\,(\Delta)_1 + \pi''\mathrm{P}_1,$$

and for the second run, and the following limb of *Mars*,

$$(\mathrm{RA})_{\alpha} = \mathrm{T}_{\alpha\ \mathrm{II}} - \mathrm{E}_{\alpha\ \mathrm{II}} - (h_{\mathrm{II}} - e) + \phi\ (\Delta)_{\alpha\ \mathrm{II}},$$

$$(\mathrm{RA})_{\mathrm{II}} = \mathrm{T}_{\mathrm{II}}\ - \mathrm{E}_{\mathrm{II}}\ - (h_{\mathrm{II}} - e) + \phi\ (\Delta)_{\mathrm{II}} + \pi''\mathrm{P}_{\mathrm{II}}$$

Let

$$\mathrm{A}_{\mathrm{I}} = \mathrm{T}_{\mathrm{I}} - \mathrm{T}_{\alpha\ \mathrm{I}},$$

$$\mathrm{A}_{\mathrm{II}} = \mathrm{T}_{\mathrm{II}} - \mathrm{T}_{\alpha\ \mathrm{II}},$$

so that A_{I} and A_{II} are either positive or negative according as the star precedes or follows the planet Then, at the sidereal time S_{I}, or $\mathrm{T}_{\mathrm{I}} - \mathrm{E}_{\mathrm{I}}$, we have

$$(\mathrm{RA})_{\mathrm{I}} = (\mathrm{RA})_{\alpha} + \mathrm{A}_{\mathrm{I}} - \frac{\mathrm{A}_{\mathrm{I}}\mathrm{R}_{\mathrm{I}}}{86400} + \pi''\mathrm{P} + \phi\ (\Delta)_{\mathrm{I}} - \phi\ (\Delta)_{\alpha\ \mathrm{I}};$$

where R_{I} is the clock rate in one sidereal day at the time S_{I}, and where A_{I} is expressed in seconds of time.

Similarly, at the sidereal time S_{II}, or $\mathrm{T}_{\mathrm{II}} - \mathrm{E}_{\mathrm{II}}$, we have

$$(\mathrm{RA})_{\mathrm{II}} = (\mathrm{RA})_{\alpha} + \mathrm{A}_{\mathrm{II}} - \frac{\mathrm{A}_{\mathrm{II}}\mathrm{R}_{\mathrm{II}}}{86400} + \pi''\mathrm{P} + \phi\ (\Delta)_{\mathrm{II}} - \phi\ (\Delta)_{\alpha\ \mathrm{I}}.$$

Let

$$\mathrm{S} = \frac{1}{2}\ (\mathrm{S}_{\mathrm{I}} + \mathrm{S}_{\mathrm{II}}),$$

$$(\mathrm{RA}) = \frac{1}{2}\ \{(\mathrm{RA})_{\mathrm{I}} + (\mathrm{RA})_{\mathrm{II}}\},$$

$$\mathrm{A} = \frac{1}{2}\ (\mathrm{A}_{\mathrm{I}} + \mathrm{A}_{\mathrm{II}}),$$

$$\mathrm{P} = \frac{1}{2}\ (\mathrm{P}_{\mathrm{I}} + \mathrm{P}_{\mathrm{II}}),$$

$$\mathrm{R} = \frac{1}{2}\ (\mathrm{R}_{\mathrm{I}} + \mathrm{R}_{\mathrm{II}}),$$

$$\phi\ (\Delta) = \frac{1}{2}\ \{\phi\ (\Delta)_{\mathrm{I}} + \phi\ (\Delta)_{\mathrm{II}}\},$$

$$\phi\ (\Delta)_{\alpha} = \frac{1}{2}\ \{\phi\ (\Delta)_{\alpha\ \mathrm{I}} + \phi\ (\Delta)_{\alpha\ \mathrm{II}}\},$$

then, at the epoch S,

$$(\mathrm{RA}) = (\mathrm{RA})_{\alpha} + \mathrm{A} - \frac{\mathrm{AR}}{86400} + \pi''\mathrm{P} + \phi\ (\Delta) - \phi\ (\Delta)_{\alpha},$$

and of course (RA) is the Apparent Right Ascension of the centre of the figure of *Mars*

Now each pair of runs gives a similar equation, and for each evening and morning the pairs must be combined together for comparison

Let $S_1, S_2, S_3 \cdot \quad S_n$ be the epochs of the evening pairs, and let

$$S_\epsilon = \frac{1}{n}(S_1 + S_2 + S_3 + \qquad S_n),$$

so that S_ϵ is the evening epoch

Let

$$\begin{aligned} \tau_1 &= S_\epsilon - S_1, \\ \tau_2 &= S_\epsilon - S_2, \\ \tau_3 &= S_\epsilon - S_3, \\ \\ \tau_n &= S_\epsilon - S_n \end{aligned}$$

Then if $(RA)_\epsilon$ be the Apparent Right Ascension of *Mars*, m_ϵ its motion in R A in 24 sidereal hours, and $\frac{dm_\epsilon}{dt}$ its daily variation in R A, all for the epoch S_ϵ, we have

$$\begin{aligned} (RA)_\epsilon &= (RA)_1 + \tau_1 m_\epsilon + \frac{\tau_1^2}{2}\frac{dm_\epsilon}{dt}, \\ (RA)_\epsilon &= (RA)_2 + \tau_2 m_\epsilon + \frac{\tau_2^2}{2}\frac{dm_\epsilon}{dt}, \\ (RA)_\epsilon &= (RA)_3 + \tau_3 m_\epsilon + \frac{\tau_3^2}{2}\frac{dm_\epsilon}{dt}, \\ \\ (RA)_\epsilon &= (RA)_n + \tau_n m_c + \frac{\tau_n^2}{2}\frac{dm_\epsilon}{dt} \end{aligned}$$

Taking the arithmetical mean of these values of $(RA)_\epsilon$, we have

$$\begin{aligned} (RA)_\epsilon = {} & \frac{1}{n}\{(RA)_1 + (RA)_2 + (RA)_3 + \qquad (RA)_n\} \\ & + \frac{1}{2n}\frac{dm_\epsilon}{dt}(\tau_1^2 + \tau_2^2 + \tau_3^2 + \qquad \tau_n^2) \end{aligned}$$

as the sum of the terms $\tau_1 + \tau_2 + \tau_3 + \qquad \tau_n$ vanishes

Let

$$A_\epsilon = \frac{1}{n}(A_1 + A_2 + A_3 + \quad A_n),$$

$$P_\epsilon = \frac{1}{n}(P_1 + P_2 + P_3 + \quad P_n),$$

$$R_\epsilon = \frac{1}{n}(R_1 + R_2 + R_3 + \quad R_n),$$

$$\phi(\Delta)_\epsilon = \frac{1}{n}\{\phi(\Delta)_1 + \phi(\Delta)_2 + \quad \phi(\Delta)_n\},$$

$$\phi(\Delta)_{a\ \epsilon} = \frac{1}{n}\{\phi(\Delta)_{a\ 1} + \phi(\Delta)_{a\ 2} + \quad \phi(\Delta)_{a\ n}\},$$

$$\tau_\epsilon^2 = \frac{1}{n}(\tau_1^2 + \tau_2^2 + \tau_3^2 + \quad \tau_n^2),$$

and then for the evening group, at the epoch S_ϵ,

$$(RA)_\epsilon = (RA)_a + A_\epsilon - \frac{A_\epsilon R_\epsilon}{86400} + \pi'' P_c + \phi(\Delta)_\epsilon - \phi(\Delta)_{a\ \epsilon} + \frac{\tau_\epsilon^2}{2}\frac{dm_\epsilon}{dt}$$

Similarly for the morning group, but now allowance must be made for the motion of the comparison star in R A due to the recession of the First Point of *Aries*

Let t_ϵ be the Greenwich mean time corresponding to the evening epoch S_ϵ, and let t_ω be the Greenwich mean time corresponding to the morning epoch S_ω, then t_ϵ and t_ω may be found from the column "Sidereal time at Greenwich mean noon" in the *Nautical Almanac*, taking the longitude to be $5^h\ 11^m\ 10^s$ to the west of Greenwich; and let t_ϵ and t_ω be expressed in terms of a mean solar day

Then, as $(RA)_a$ is the Apparent Right Ascension of the star at the evening epoch,

$$(RA)_a + (t_\omega - t_c)\frac{d\,(RA)_a}{dt}$$

will be the Apparent Right Ascension of the star at the morning epoch, where $\frac{d\,(RA)_a}{dt}$, the daily variation, may be computed from the formulæ in the *Nautical Almanac*, p 296

But as it will prove exceedingly troublesome to compute $\frac{d\,(RA)_a}{dt}$ for every night, we must introduce the principle of tabulation by referring this correction to the planet Thus if $\overline{m}$ be the motion of *Mars* in R A due to the recession of the equinoctial point, and if $(\mathrm{RA})_\omega$ be the Apparent Right Ascension of *Mars* at the morning epoch,

$$(\mathrm{RA})_\omega-(t_\omega-t_\epsilon)\,\overline{m}$$

will be the Apparent Right Ascension of *Mars* at the same epoch, but referred to the Equinox of the preceding evening epoch The following are the daily variations of R A of *Mars* due to the recession of the equinoctial point, for intervals of 15 days during the Opposition in 1877 —

At Greenwich Mean Midnight	$\overline{m}$ s
August 7	+0·022
August 22	+0·016
September 6	+0·008
September 21	0·000

and the correction for any other intermediate date may be found by simple proportion

Thus for the morning group, at the epoch S_ω, we have

$$(\mathrm{RA})_\omega=(\mathrm{RA})_a+\mathrm{A}_\omega-\frac{\mathrm{A}_\omega\mathrm{R}_\omega}{86400}+\pi''\,\mathrm{P}_\omega+\phi\,(\Delta)_\omega-\phi\,(\Delta)_{a\,\omega}+\frac{\tau_\omega{}^2}{2}\,\frac{dm_\omega}{dt}+(t_\omega-t_\epsilon)\,m$$

Let $\frac{d\mathrm{R}}{dt}$ be the change in the clock rate in 24 hours for the epoch intermediate between S_ϵ and S_ω, then

$$\mathrm{R}_\omega=\mathrm{R}_\epsilon+(t_\omega-t_\epsilon)\,\frac{d\mathrm{R}}{dt}\,,$$

and by subtraction

$$(\mathrm{RA})_\omega-(\mathrm{RA})_\epsilon=\mathrm{A}_\omega-\mathrm{A}_\epsilon-\frac{\mathrm{A}\,(t_\omega-t_\epsilon)}{86400}\,\frac{d\mathrm{R}}{dt}+\pi''\,(\mathrm{P}_\omega-\mathrm{P}_\epsilon)+\{\phi\,(\Delta)_\omega-\phi\,(\Delta)_{a\,\omega}\}$$
$$-\{\phi\,(\Delta)_\epsilon-\phi\,(\Delta)_{a\,\epsilon}\}+\frac{1}{2}\,\frac{dm}{dt}\,(\tau_\omega{}^2-\tau_\epsilon{}^2)+(t_\omega-t_\epsilon)\,m,$$

where A and $\frac{dm}{dt}$ may have their mean values for the night

If the observations are made regularly, the term $\frac{1}{2}\frac{dm}{dt}(\tau_\omega^2-\tau_\epsilon^2)$ will vanish; indeed, whether they are made regularly or not, if the observations are completed within an hour or so each evening and morning, the term will be quite insensible, and may therefore be neglected

Let m, $\frac{dm}{dt}$, $\frac{d^2m}{dt^2}$, be the apparent daily motion of *Mars* in R A, and its variations, at the preceding Greenwich mean noon, and let m, $\frac{dm}{dt}$, $\frac{d^2m}{dt^2}$ be taken from the *Nautical Almanac* by employing differences in the following manner.

Arranging the terms thus—

	First diff	Second diff
$(RA)_{-2}$		
	D_1'	
$(RA)_{-1}$		D_1''
	D_2'	
$(RA)_0$		D_2''
	D_3'	
$(RA)_{+1}$		D_3''
	D_4'	
$(RA)_{+2}$		

it may easily be shown that, for the epoch represented by the suffix $(_o)$,

$$m = \frac{d\,(RA)_o}{dt} = \frac{1}{12}\{7\,(D_2'+D_3')-(D_1'+D_4')\},$$

$$\frac{dm}{dt} = \frac{d^2\,(RA)_o}{dt^2} = \frac{1}{12}\{14\,D_2''-(D_1''+D_3'')\},$$

$$\frac{d^2m}{dt^2} = \frac{d^3\,(RA)_o}{dt^3} = \frac{1}{2}\,(D_3''-D_1'')$$

The values of m, $\frac{dm}{dt}$, $\frac{d^2m}{dt^2}$ thus found include fourth differences, but as m may be somewhat in error, we shall suppose that the true motion is $m+\delta m$, where δm is to be found from meridian observations at the large Observatories.

Thus we have

$$(RA)_\omega-(RA)_\epsilon = (t_\omega-t_\epsilon)\,m+\frac{1}{2}\,(t_\omega^2-t_\epsilon^2)\,\frac{dm}{dt}+\frac{1}{6}\,(t_\omega^3-t_\epsilon^3)\,\frac{d^2m}{dt^2}+(t_\omega-t_\epsilon)\,\delta m\,,$$

and substituting and arranging, we have for the final equation of the Solar Parallax as deduced from the observed star, or say from the first star,

$$(P_\omega - P_\epsilon)\,\pi'' = A_\epsilon - A_\omega + (t_\omega - t_\epsilon)\,(m - \overline{m}) + \frac{1}{2}\,(t_\omega{}^2 - t_\epsilon{}^2)\,\frac{dm}{dt} + \frac{1}{6}\,(t_\omega{}^3 - t_\epsilon{}^3)\,\frac{d^2m}{dt^2} + \frac{A\,(t_\omega - t_\epsilon)}{86400}\,\frac{dR}{dt}$$

$$+ \{\phi\,(\Delta)_\epsilon - \phi\,(\Delta)_{a\ \epsilon}\} - \{\phi\,(\Delta)_\omega - \phi\,(\Delta)_{a\ \omega}\} + (t_\omega - t_\epsilon)\,\delta m \qquad (a)$$

Now suppose that two stars were observed in the same run with the planet; the groups would then consist of observations made in the following order.—

First run	First star	(a_{I})
	Second star	(b_{I})
	Mars I	(I)
Second run	First star	(a_{II})
	Second star	(b_{II})
	Mars II	(II)

The planet should really be intermediate in both R A and N P D if possible, but the above order is referred to for the sake of symmetry in the equations

Let B and b apply to the second star exactly as A and a applies to the first; then the final equation for the Solar Parallax as deduced from the second star will be

$$(P_\omega - P_\epsilon)\,\pi'' = B_\epsilon - B_\omega + (t_\omega - t_\epsilon)\,(m - \overline{m}) + \frac{1}{2}\,(t_\omega{}^2 - t_\epsilon{}^2)\,\frac{dm}{dt} + \frac{1}{6}\,(t_\omega{}^3 - t_\epsilon{}^3)\,\frac{d^2m}{dt^2} + \frac{B\,(t_\omega - t_\epsilon)}{86400}\,\frac{dR}{dt}$$

$$+ \{\phi\,(\Delta)_\epsilon - \phi\,(\Delta)_{b\ \epsilon}\} - \{\phi\,(\Delta)_\omega - \phi\,(\Delta)_{b\ \omega}\} + (t_\omega - t_\epsilon)\,\delta m \qquad (\beta)$$

Now let

$$C = \frac{1}{2}\,(A + B)$$

$$(RA)_c = \frac{1}{2}\,\{(RA)_a + (RA)_b\}$$

$$\Delta_c = \frac{1}{2}\,(\Delta_a + \Delta_b)$$

$$\phi\,(\Delta)_c = \frac{1}{2}\,\{\phi\,(\Delta)_a + \phi\,(\Delta)_b\},$$

so that the measures and functions are all referred to the point midway between the two stars, then, from (α) and (β)

$$(P_\omega - P_\epsilon)\, \pi'' = C_\epsilon - C_\omega + (t_\omega - t_\epsilon)\,(m - \bar{m}) + \frac{1}{2}\,(t_\omega^2 - t_\epsilon^2)\,\frac{dm}{dt} + \frac{1}{6}\,(t_\omega^3 - t_\epsilon^3)\,\frac{d^2m}{dt^2} + \frac{C\,(t_\omega - t_\epsilon)}{86400}\,\frac{dR}{dt}$$

$$+ \{\phi\,(\Delta)_\epsilon - \phi\,(\Delta)_{c\ \epsilon}\} - \{\phi\,(\Delta)_\omega - \phi\,(\Delta)_{c\ \omega}\} + (t_\omega - t_\epsilon)\,\delta m \qquad (\gamma)$$

Now the advantage gained by the latter method is this, that as the true difference of R A between the two stars does not change during the night, we can obtain another equation, and then eliminate from (γ) either $\frac{dR}{dt}$ or the functions of Δ, as circumstances may require

Thus, referring to the primary equations,

$$(RA)_a = T_a - E_a - (h - e) + \phi\,(\Delta)_a,$$
$$(RA)_b = T_b - E_b - (h - e) + \phi\,(\Delta)_b,$$

and if

$$T_b - T_a = D, \; (= A - B),$$

we have

$$(RA)_b - (RA)_a = D - \frac{DR}{86400} + \phi\,(\Delta)_b - \phi\,(\Delta)_a$$

Subtracting the morning results from the evening results, and arranging,

$$D_\omega - D_\epsilon = \frac{D\,(t_\omega - t_\epsilon)\,\frac{dR}{dt}}{86400} + \{\phi\,(\Delta)_{b\ \epsilon} - \phi\,(\Delta)_{a\ \epsilon}\} - \{\phi\,(\Delta)_{b\ \omega} - \phi\,(\Delta)_{a\ \omega}\}$$

If $\frac{dR}{dt}$ can be depended on, the whole correction for a difference $\Delta_b - \Delta_a$ in North Polar Distance is known, and then the correction for a difference $\Delta - \Delta_c$ may be found by proportion

But if the refraction is uniform, and the instrument stable, while the clock is untrustworthy, the corrections may be computed, and $\frac{dR}{dt}$ eliminated from γ).

Lastly, as we have introduced a correction for m, the evening observations of one day may be combined if necessary with the morning observations made one or two days before or afterwards, provided that the same star or comparison-point were employed on both occasions, or provided that special measures were taken to connect them

SECTION III.

Clock Error, Rate, etc

Barometer and Thermometer

Errors of Adjustment of the Equatoreal.

Transits observed with the Equatoreal (reduced to the mean wire).

NOTES—The stars are numbered according to the list given in the *Monthly Notices*, November 1875 They are included with *Mars* in brackets, thus { }, and in order according to their sequence in R A

The runs are numbered for each night according to their sequence, the odd numbers always refer to the first limb of *Mars*, the even numbers to the second limb

The only additional star employed is *c* · mag 7½, R.A. 23h 8m 56s, N P D 102° 14′ See *Nature*, December 14, 1876

The runs are divided into groups by horizontal lines.

Clock Error, Rate, &c

Day.		Sid Time h	m	Interval *t* days	Error E s	Rate R s	Half the Change $\frac{1}{2}\left(\frac{dR}{dt}\right)$ s
August	5	2	37	1 02	−23 76	−1 51	−1 23
	6	3	5	0 99	26 56	−2 81	−0 06
	7	2	46	2 00	29 39	−2 39	+0 47
	9	2	46	1 00	32 27	−1 20	+0 12
	10	2	46	1 01	33 36	−1 67	−0 58
	11	3	5	1 00	35 64	−1 64	+0 61
	12	3	5	2 00	36 67	−0 86	+0 17
	14	3	5	1 01	37 73	−1 15	−0 31
	15	3	21	1 00	39 21	−0 16	+1 30
	16	3	27	2 01	38 07	+0 74	−0 40
	18	3	46	3 00	38 17	−0 51	−0 23
	21	3	46	1 00	41 72	−0 76	+0 14
	22	3	52	1 06	42 33	−0 44	+0 17
	23	5	25	1 09	42 58	−0 99	−0 70
	24	7	29	1 94	44 49	−1 14	+0 56
	26	6	1	2 92	44 57	+0 10	+0 07
	29	4	6	2 05	43 73	−0 21	−0 17
	31	5	24	2 01	44 84	−0 99	−0 22
September	2	5	39	1 03	47 73	−0 52	+0 46
	3	6	23	1 94	47 78	−0 23	−0 17
	5	4	55	1 11	48 82	−0 05	+0 25
	6	7	29	0 96	48 59	−1 07	−1 15
	7	6	9	4 02	50 67	−1 61	+0 58
	11	6	35	2 01	47 86	−1 95	−0 66
	13	6	52	1 00	54 45	−3 80	−0 26
	14	6	57	2 00	58 52	−3 78	+0 29
	16	6	52	1 03	4 94	−3 49	−0 14
	17	7	38	7 10	8 68	−3 47	+0 16
	24	10	7		−25 36		

Readings of the Barometer (unreduced) and of the Thermometer (exposed) F

Day		Evening		Morning	
		Barometer	Thermometer	Barometer	Thermometer
		in	°	in	°
August	6	28 33	75 2	28 28	74 5
	7	32	73 5	30	73 0
	8	34	74 0		
	9	30	74 0	25	73 0
	10	30	73 0	25	73 0
	11	30	73 0	23	73 0
	12	30	75 0	25	74 0
	14	35	75 0	29	73 0
	15	34	76 0	30	75 0
	16	33	74 0	25	74 0
	18	30	73 5	25	73 0
	21	30	75 0	28	74 0
	22	30	75 0	30	74 0
	24	28	75 0		
	25	20	74 0		
	28	28	75 0		
	29	25	74 0	24	74 0
	31	30	74 0	28	73 0
September	1	30	74 5	28	72 0
	2	31	74 0	30	73 5
	3	33	75 0		
	4	30	74 5	29	74 5
	5	30	75 0	27	73 5
	6	25	74 0	24	73 0
	7	24	74 0	21	72 0
	8	24	73 0		
	9	25	72 5	23	72 0
	10	24	72 0	20	71 0
	13	23	75 5	20	74 0
	14	25	75 0		
	17	28 20	72 0	28 19	74 0
Mean		28 29	74 2	28 26	73 3

Mean Evening value of f = 3^{s} 487

Mean Morning value of f = 3 490

Mean value adopted = 3 49

Errors of Adjustment of the Equatoreal

	v''	i''	y''
	″	″	″
July 29	26	+26	+1
August 5		+ 8	
August 5		+15	
August 16		+20	−4
August 17	19	+ 8	0
August 17	36		−7
October 8	16	+22	−4
Mean values	24	+17	−3

	c	i	u
	s	s	s
August 16	+2 8	−6 9	3 2
August 17	−0 8	−10 9	5 0
August 24	+1 0	− 8 5	3 8
August 26	+1 4	− 8 1	3 7
September 2	+2 2	− 7 5	4 9
September 3	+4 0	− 5 7	3 0
September 6	+4 4	− 5 2	2 3
September 7	−5 2	−10 5	4 9
September 16	+3 0	− 6 6	3 6
Mean values	+1 4	− 7 8	3 8

Mean value of $(i + u \cos \gamma) = -6^{\mathrm{s}}6$

August 6 { 508 *Mars* }

Transits observed with the Equatorial

East					West				
Runs	Clock Times			Intervals	Runs	Clock Times			Intervals
No	h	m	s	s	No	h	m	s	s
1	19	58	26 88	118 02	13	1	44	16 36	116 42
	20	0	24 90				46	12 78	
2		2	46 54	119 64	14		47	53 38	117 72
		4	46 18				49	51 10	
3		8	22 64	117 88	15		52	49 12	116 08
		10	20 52				54	45 20	
4		12	33 12	119 38	16		57	57 76	117 46
		14	32 50				59	55 22	
5		17	9 18	118 02	17	2	1	49 40	116 23
		19	7 20				3	45 63	
6		21	3 92	119 30	18		5	24 64	117 41
		23	3 22				7	22 05	
7	20	26	59 82	117 96	19	2	10	5 36	116 38
		28	57 78				12	1 74	
8		31	10 18	119 46	20		13	34 92	117 48
		33	9 64				15	32 40	
9		35	32 33	117 75	21		16	58 53	116 31
		37	30 08				18	54 84	
10		39	4 64	119 36	22		21	43 92	117 20
		41	4 00				23	41 12	
11		59	16 32	117 78	23		25	56 60	116 06
	21	1	14 10				27	52 66	
12		2	55 08	118 98	24		29	40 00	117 33
		4	54 06				31	37 33	

AUGUST 7

514
Mars
586

Transits observed with the Equatoreal

EAST							WEST						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	18	45	18 10	108 42			9	1	48	54 34	105 66		
		47	6 52		68 11				50	40 00		70 82	
		48	14 63			176 53			51	50 82			176 48
2		53	52 50	110 22			10		54	40 26	106 94		
		55	42 72		66 50				56	27 20		69 48	
		56	49 22			176 72			57	36 68			176 42
3	19	1	4 18	108 74			11	2	1	3 16	(105 00)		
		2	52 92		68 12				2	48 16		71 02	
		4	1 04			176 86			3	59 18			(176 02)
4		6	56 34	109 80			12		6	8 38	106 80		
		8	46 14		67 02				7	55 18		69 68	
		9	53 16			176 82			9	4 86			176 48
5	19	13	36 32	108 44			13	2	10	59 52	105 30		
		15	24 76		68 28				12	44 82		71 12	
		16	33 04			176 72			13	55 94			176 42
6		20	1 40	110 18			14		15	56 04	106 90		
		21	51 58		66 48				17	42 94		69 58	
		22	58 06			176 66			18	52 52			176 48
7		26	56 14	108 58			15		20	43 14	105 14		
		28	44 72		68 20				22	28 28		71 32	
		29	52 92			176 78			23	39 60			176 46
8		32	57 30	110 16			16		25	22 90	106 64		
		34	47 46		66 60				27	9 54		69 66	
		35	54 06			176 76			28	19 20			176 30

In the 11th run, the instrument apparently moved between the transits of 514 and *Mars* I, the interval to be employed in computing the mean is $176^{s}43-71^{s}02$, or $105^{s}41$.

AUGUST 10

{ 514
Mars
619 }

Transits observed with the Equatorial

East					West				
Runs	Clock Times	Intervals			Runs	Clock Times	Intervals		
No	h m s	s	s	s	No	h m s	s	s	s
1	19 44 36 34	84 88			9	1 34 24 73	80 00		
	46 1 22		193 36			35 44 73		197 79	
	49 14 58			278 24		39 2 52			277 79
2	51 52 03	86 22			10	41 57 02	81 70		
	53 18 25		191 83			43 18 72		196 44	
	56 30 08			278 05		46 35 16			278 14
3	59 25 08	84 90			11	49 2 66	79 50		
	20 0 49 98		193 14			50 22 16		198 68	
	4 3 12			278 04		53 40 84			278 18
4	6 48 30	86 30			12	55 1 28	81 40		
	8 14 60		191 68			56 22 68		196 72	
	11 26 28			277 98		59 39 40			278 12
5	20 14 26 34	84 74			13	2 3 56 44	79 50		
	15 51 08		193 52			5 15 94		198 32	
	19 4 60			278 26		8 34 26			277 82
6	22 40 56	86 16			14	10 43 72	80 86		
	24 6 72		191 86			12 4 58		197 02	
	27 18 58			278 02		15 21 60			277 88
7	30 54 90	84 22			15	19 17 10	79 66		
	32 19 12		193 80			20 36 76		198 46	
	35 32 92			278 02		23 55 22			278 12
8	39 1 52	85 60			16	26 20 22	80 90		
	40 27 12		192 38			27 41 12		197 13	
	43 39 50			277 98		30 58 25			278 03

AUGUST 11

$\left\{\begin{array}{c}514\\ \textit{Mars}\\ 565\end{array}\right\}$

Transits observed with the Equatoreal

EAST							WEST						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	51	51 54				9	1	52	57 86			
		53	2 34	70 80					54	2 72	64 86		
		54	3 10		60 76	131 56			55	9 42		66 70	131 56
2		56	16 38				10		57	38 60			
		57	28 90	72 52					58	45 06	66 46		
		58	28 08		59 18	131 70			59	50 26		65 20	131 66
3	20	1	31 40				11	2	2	0 34			
		2	42 08	70 68					3	5 06	64 72		
		3	43 08		61 00	131 68			4	12 08		67 02	131 74
4		6	13 64				12		6	28 16			
		7	25 84	72 20					7	34 40	66 24		
		8	25 08		59 24	131 44			8	39 86		65 46	131 70
5	20	13	24 26				13	2	10	41 12			
		14	34 90	70 64					11	45 82	64 70		
		15	35 90		61 00	131 64			12	52 88		67 06	131 76
6		18	12 25				14		14	51 86			
		19	24 22	71 97					15	58 08	66 22		
		20	24 02		59 80	131 77			17	3 48		65 40	131 62
7		31	43 32				15		19	26 12			
		32	53 46	70 14					20	30 74	64 62		
		33	55 00		61 54	131 68			21	38 00		67 26	131 88
8		37	11 72				16		23	52 74			
		38	23 23	(71 51)					24	58 74	66 00		
		39	23 00		59 77	(131 28)			26	4 32		65 58	131 58

The instrument apparently moved in the 8th run, between the transits of 514 and *Mars* II, the interval to be employed is $131^{s}64-59^{s}77$, or $71^{s}87$.

AUGUST 12

{ *Mars* }
{ 565 }

Transits observed with the Equatoreal

East					West				
Runs	Clock Times			Intervals	Runs	Clock Times			Intervals
No	h	m	s	s	No	h	m	s	s
1	19	40	59 74	77 56	17	1	58	4 18	85 00
		42	17 30				59	29 18	
2		43	42 42	75 96	18	2	0	59 18	83 60
		44	58 38				2	22 78	
3		46	26 04	77 90	19		3	50 94	85 04
		47	43 94				5	15 98	
4		48	53 25	76 25	20		7	4 88	83 34
		50	9 50				8	28 22	
5		52	32 84	77 78	21		10	34 58	85 26
		53	50 62				11	59 84	
6		55	8 14	76 14	22		13	25 94	83 42
		56	24 28				14	49 36	
7		57	52 60	78 06	23		16	15 06	85 16
		59	10 66				17	40 22	
8	20	0	32 04	76 28	24		19	21 20	83 84
		1	48 32				20	45 04	
9	20	4	31 70	78 08	25	2	22	44 04	85 12
		5	49 78				24	9 16	
10		7	12 00	(76 12)	26		25	25 10	83 86
		8	28 12				26	48 96	
11		9	55 88	78 16	27		27	25 88	85 30
		11	14 04				28	51 18	
12		12	32 08	76 72	28		30	10 12	83 96
		13	48 80				31	34 08	
13		16	4 72	78 30	29		35	3 00	85 54
		17	23 02				36	28 54	
14		18	45 16	76 86	30		37	43 28	84 14
		20	2 02				39	7 42	
15		21	40 92	78 38	31		40	57 20	85 68
		22	59 30				42	22 88	
16		24	45 56	76 92	32		43	57 13	84 13
		26	2 48				45	21 26	

The instrument apparently moved in the 10th run, the interval to be employed is the mean of the 8th and 12th, or $76^{s}50$

AUGUST 14

{*Mars*
565}

Transits observed with the Equatoreal

EAST					WEST				
Runs	Clock Times			Intervals	Runs	Clock Times			Intervals
No	h	m	s	s	No	h	m	s	s
1	20	47	5 84	122 51	11	1	37	52 00	129 40
		49	8 35				40	1 40	
2		51	25 12	121 02	12		41	41 16	127 70
		53	26 14				43	48 86	
3		55	11 10	122 73	13		46	37 02	129 52
		57	13 83				48	46 54	
4		58	48 08	121 18	14		50	26 16	127 94
	21	0	49 26				52	34 10	
5		3	8 16	122 94	15		54	55 08	129 88
		5	11 10				57	4 96	
6		6	46 74	121 38	16		58	24 78	128 02
		8	48 12			2	0	32 80	
7	21	15	10 92	123 16	17		8	14 72	130 01
		17	14 08				10	24 73	
8		19	43 94	121 84	18			48 08	128 30
		21	45 78				13	56 38	
9		24	50 16	123 39	19	2	16	27 20	130 02
		26	53 55				18	37 22	
10		29	0 28	122 02	20		20	23 04	128 46
		31	2 30				22	31 50	
					21		27	11 92	130 22
							29	22 14	
					22		31	4 12	128 72
							33	12 84	
					23		36	8 98	130 37
							38	19 35	
					24		39	56 92	129 06
							42	5 98	
					25		44	4 06	130 80
							46	14 86	
					26		47	39 16	129 10
							49	48 26	

August 15

{ 463 }
{ *Mars* }
{ 565 }

Transits observed with the Equatorial

East							West						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	
1	19	2	16 84	118 80			9	2	3	0 66	108 29		
		4	15 64		146 38				4	48 95		156 95	
		6	42 02			265 18			7	25 90			265 24
2		9	56 24	120 22			10		13	52 44	109 74		
		11	56 46		145 18				15	42 18		155 62	
		14	21 64			265 40			18	17 80			265 36
3		25	6 10	118 22			11		22	49 04	107 92		
		27	4 32		146 86				24	36 96		157 20	
		29	31 18			265 08			27	14 16			265 12
4		33	45 74	119 64			12		31	18 32	109 56		
		35	45 38		145 52				33	7 88		155 70	
		38	10 90			265 16			35	43 58			265 26
5	19	42	9 40	118 18			13	2	39	26 10	107 36		
		44	7 58		147 28				41	13 46		157 88	
		46	34 86			265 46			43	51 34			265 24
6		49	47 66	119 48			14		46	3 40	108 90		
		51	47 14		145 90				47	52 30		156 40	
		54	13 04			265 38			50	28 70			265 30
7		59	3 36	117 44			15		52	46 92	107 22		
	20	1	0 80		147 96				54	34 14		157 96	
		3	28 76			265 40			57	12 10			265 18
8		6	48 18	119 06			16						
		8	47 24		146 26			3	2	27 14		156 80	
		11	13 50			265 32			5	3 94			

In the 16th run the star 463 was not visible on account of daylight, the interval to be employed is $265^{s}24 - 156^{s}80$, or $108^{s}44$

AUGUST 16

{Mars 565 619}

Transits observed with the Equatoreal

East							
Runs	Clock Times			Intervals			
No	h	m	s	s	s	s
1	19	6	19 08			
		9	14 88	175 80		
		11	41 06		146 18	321 98
2		14	36 00			
		17	30 08	174 08		
		19	56 27		146 19	320 27
3		24	54 36			
		27	50 34	175 98		
		30	16 72		146 38	322 36
4		33	34 22			
		36	28 82	174 60		
		38	55 06		146 24	320 84
5		46	1 06			
		48	57 52	176 46		
		51	24 12		146 60	323 06
6		55	27 30			
		58	22 27	174 97		
	20	0	48 76		146 49	321 46

West						
Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
7	1	38	52 10			
		41	58 24	186 14		
		44	24 56		146 32	332 46
8		46	38 32			
		49	42 90	184 58		
		52	9 32		146 42	331 00
9		54	54 94			
		58	1 70	186 76		
	2	0	27 80		146 10	332 86
10		4	36 14			
		7	41 55	185 41		
		10	7 90		146 35	331 76
11	2	12	18 14			
		15	25 08	186 94		
		17	51 60		146 52	333 46
12		20	8 52			
		23	13 98	185 46		
		25	40 50		146 52	331 98
13		41	20 90			
		44	28 30	187 40		
		46	54 88		146 58	333 98
14		49	11 58			
		52	18 08	186 50		
		54	44 20		146 12	332 62

From the clock times of the evening observations of August 15 and 16 it has been necessary to subtract one hour In each case the final equation for parallax required this correction, and in each case the necessity of the correction may be indirectly inferred from notes made at the time, as no cause is stated for the delay which must otherwise have occurred

August 18

(377)
(*Mars*)

Transits observed with the Equatoreal

East			West		
Runs	Clock Times	Intervals	Runs	Clock Times	Intervals
No	h m s	s	No	h m s	s
1	20 24 5 48	276 62	9	1 29 53 22	267 60
	28 42 10			34 20 82	
2	31 10 08	278 48	10	36 47 00	268 90
	35 48 56			41 15 90	
3	37 52 22	276 16	11	45 9 82	266 60
	42 28 38			49 36 42	
4	44 47 98	278 06	12	54 6 24	268 20
	49 26 04			58 34 44	
5	51 52 40	275 74	13	2 1 43 34	266 62
	56 28 14			6 9 96	
6	58 42 10	277 32	14	8 55 26	267 80
	21 3 19 42			13 23 06	
7	6 57 98	275 28	15	16 51 88	265 80
	11 33 26			21 17 68	
8	13 18 64	276 82	16	24 48 14	267 50
	17 55 46			29 15 64	
			17	2 31 56 14	265 24
				36 21 38	
			18	38 46 06	266 88
				43 12 94	
			19	46 9 12	264 94
				50 34 06	
			20	53 8 02	266 30
				57 34 32	
			21	3 0 41 04	264 68
				5 5 72	
			22	7 12 70	265 96
				11 38 66	

AUGUST 21

{377 Mars 463}

Transits observed with the Equatoreal

EAST

Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
1	18	48	57 04	159 92		
		51	36 96		95 76	
		53	12 72			255 68
2		56	0 92	161 26		
		58	42 18		94 22	
	19	0	16 40			255 48
3		3	48 78	159 44		
		6	28 22		96 28	
		8	4 50			255 72
4		11	30 88	161 10		
		14	11 98		94 78	
		15	46 76			255 88
5		18	34 84	159 18		
		21	14 02		96 38	
		22	50 40			255 56
6		26	32 88	160 36		
		29	13 24		95 52	
		30	48 76			255 88
7	19	33	21 10	158 60		
		35	59 70		97 22	
		37	36 92			255 82
8		40	15 24	160 00		
		42	55 24		95 74	
		44	30 98			255 74
9		48	9 08	157 84		
		50	46 92		97 66	
		52	24 58			255 50
10		55	32 40	159 68		
		58	12 08		96 20	
		59	48 28			255 88

WEST

Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
11	1	53	53 08	144 82		
		56	17 90		111 04	
		58	8 94			255 86
12	2	5	42 30	146 06		
		8	8 36		109 66	
		9	58 02			255 72
13		12	49 22	144 44		
		15	13 66		111 42	
		17	5 08			255 86
14		18	37 14	145 72		
		21	2 86		110 10	
		22	52 96			255 82
15		26	29 32	143 66		
		28	52 98		112 16	
		30	45 14			255 82
16		34	2 90	145 06		
		36	27 96		110 70	
		38	18 66			255 76
17	2	41	42 18	142 92		
		44	5 10		112 90	
		45	58 00			255 82
18		48	50 00	144 62		
		51	14 62		110 84	
		53	5 46			255 46
19		56	15 64	142 48		
		58	38 12		113 06	
	3	0	31 18			255 54
20		3	7 72	144 20		
		5	31 92		111 68	
		7	23 60			256 88
21		10	17 48	142 06		
		12	39 54		113 54	
		14	33 08			255 60
22		16	37 36	143 74		
		19	1 10		112 06	
		20	53 16			255 80

AUGUST 22 {377 *Mars* 453}

Transits observed with the Equatorial

EAST							WEST						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	44	3 16	113 60			9	2	12	55 88	98 78		
		45	56 76		105 30				14	34 66		120 16	
		47	42 06			218 90			16	34 82			218 94
2		49	58 22	114 86			10		20	0 08	100 04		
		51	53 08		103 82				21	40 12		118 68	
		53	36 90			218 68			23	38 80			218 72
3		56	19 02	113 06			11		25	59 40	98 44		
		58	12 08		105 85				27	37 84		120 58	
		59	57 93			218 91			29	38 42			219 02
4	20	2	17 10	114 40			12		32	6 46	99 74		
		4	11 50		104 30				33	46 20		119 16	
		5	55 80			218 70			35	45 36			218 90
5		8	14 68	112 54			13	2	39	2 96	97 74		
		10	7 22		106 22				40	40 70		121 14	
		11	53 44			218 76			42	41 84			218 88
6		16	13 24	114 08			14		45	29 14	98 98		
		18	7 32		104 88				47	8 12		119 78	
		19	52 20			218 96			49	7 90			218 76
7		22	40 08	111 96			15	3	2	4 72	96 88		
		24	32 04		106 86				3	41 60		121 84	
		26	18 90			218 82			5	43 44			218 72
8		28	36 28	113·74			16		9	22 54	98 42		
		30	30 02		105·08				11	0 96		120 50	
		32	15 10			218 82			13	1 46			218 92
							17		17	11 16	96 44		
									18	47 60		122 44	
									20	50 04			218 88
							18		22	18 40	97 86		
									23	56 26		120 94	
									25	57 20			218 80

AUGUST 24

{ 286 *Mars* 453 }

Transits observed with the Equatoreal

Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
1	19	30	47 08			
		35	57 80	310 72		
		39	19 36		201 56	512 28
2		52	0 90			
		57	12 26	311 36		
	20	0	33 08		200 82	512 18
3		9	14 10			
		14	23 16	309 06		
		17	46 28		203 12	512 18
4		20	57 36			
		26	7 78	310 42		
		.				
5		35	45 44			
		40	53 44	308 00		
		44	17 63		204 19	512 19
6		52	2 98			
		57	12 06	309 08		
	21	0	35 18		203 12	512 20

In the 4th run clouds obscured the transit of 453; the required interval is $512^{s}21-310^{s}42$, or $201^{s}79$

AUGUST 25

{ 309 *Mars* 453 }

Transits observed with the Equatoreal

EAST							
Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
1	18	45	0 10			
		48	3 20	183 10		
		52	14 70		251 50	434 60
2		55	9 28			
		58	13 38	184 10		
	19	2	24 05		250 67	434 77
3		5	10 50			
		8	13 02	182 52		
		12	25 10		252 08	434 60
4		15	19 42			
		18	23 66	184 24		
		22	34 22		250 56	434 80
5	19	25	31 70			
		28	33 34	181 64		
		32	46 40		253 06	434 70
6		35	23 06			
		38	26 10	183 04		
		42	37 94		251 84	434 88
7		45	9 50			
		48	10 40	180 90		
		52	24 10		253 70	434 60
8		55	33 74			
		58	36 00	182 26		
	20	2	48 58		252 58	434 84

AUGUST 28

{286 *Mars* 365}

Transits observed with the Equatoreal

Runs	East					
	Clock Times			Intervals		
No	h	m	s	s	s	s
1	18	25	10 52			
		26	46 74	96 22		
		29	15 12		148 38	244 60
2		32	4 04			
		33	41 46	97 42		
		36	8 44		146 98	244 40
3		39	21 98			
		40	57 08	95 10		
		43	26 38		149 30	244 40
4		45	6 06			
		46	43 06	97 00		
		49	10 44		147 38	244 38
5	18	59	2 12			
	19	0	36 80	94 68		
		3	6 54		149 74	244 42
6		5	7 08			
		6	43 26	96 18		
		9	11 66		148 40	244 58
7		15	17 14			
		16	50 94	93 80		
		19	21 38		150 44	244 24
8		21	22 22			
		22	57 60	95 38		
		25	26 52		148 92	244 30
9	19	30	31 76			
		32	4 86	93 10		
		34	36 12		151 26	244 36
10		36	53 44			
		38	28 06	94 62		
		40	58 00		149 94	244 56
11		46	21 38			
		47	53 82	92 44		
		50	25 76		151 94	244 38
12		52	7 60			
		53	41 46	93 86		
		56	12 08		150 62	244 48

August 29 { 253 *Mars* 365 }

Transits observed with the Equatoreal

East							West						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	8	55 50	112 48			9	1	55	47 84	93 34		
		10	47 98		209 10				57	21 18		228 28	
		14	17 08			321 58		2	1	9 46			321 62
2		17	34 78	113 80			10		3	32 00	94 86		
		19	28 58		207 58				5	6 86		226 88	
		22	56 16			321 38			8	53 74			321 74
3		26	44 10	111 64			11		13	56 86	92 64		
		28	35 74		209 74				15	29 50		228 74	
		32	5 48			321 38			19	18 24			321 38
4		34	27 26	113 20			12		21	54 82	93 92		
		36	20 46		208 46				23	28 74		227 48	
		39	48 92			321 66			27	16 22			321 40
5	19	45	59 06	110 86			13	2	32	9 02	91·90		
		47	49 92		210 68				33	40 92		229 58	
		51	20 60			321 54			37	30 50			321 48
6		55	39 24	112 32			14		41	27 82	93 14		
		57	31 56		209 30				43	0 96		228 30	
	20	1	0 86			321 62			46	49 26			321 44
7		4	11 70	109 96			15		51	8 64	90 88		
		6	1 66		211 40				52	39 52		230 48	
		9	33 06			321 36			56	30 00			321 36
8		12	36 38	111 62			16	3	11	42 58	91 58		
		14	28 00		210 14				13	14 16		229 98	
		17	58 14			321 76			17	4 14			321 56

AUGUST 31

193
Mars
286

Transits observed with the Equatoreal

EAST							WEST						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	29	15 06	145 18			9	2	58	32 35	123 35		
		31	40 24		86 84			3	0	35 70		108 60	
		33	7 08			232 02			2	24 30			231 95
2		36	33 90	146 64			10		5	0 12	124 86		
		39	0 54		85 16				7	4 98		107 22	
		40	25 70			231 80			8	52 20			232 08
3		43	53 58	144 30			11		11	31 52	122 66		
		46	17 88		87 62				13	34 18		109 54	
		47	45 50			231 92			15	23 72			232 20
4		51	18 26	146 08			12		17	12 56	124 26		
		53	44 34		85 94				19	16 82		107 84	
		55	10 28			232 02			21	4 66			232 10
5	19	58	48 12	143 94			13	3	24	12 00	122 02		
	20	1	12 06		88 14				26	14 02		110 12	
		2	40 20			232 08			28	4 14			232 14
6		5	2 28	145 54			14		34	16 04	123 32		
		7	27 82		86 52				36	19 36		108 77	
		8	54 34			232 06			38	8 13			232 09
7		11	8 04	143 10			15		41	11 96	121 16		
		13	31 14		89 02				43	13 12		110 78	
		15	0 16			232 12			45	3 90			231 94
8		17	22 30	144 68			16		47	40 56	122 62		
		19	46 98		87 20				49	43 18		109 08	
		21	14 18			231 88			51	32 26			231 70

September 1

193
Mars
286

Transits observed with the Equatorial

East							West						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	33	50 25	82 47			9	2	12	0 56	62 78		
		35	12 72		149 40				13	3 34		169 52	
		37	42 12			231 87			15	52 86			232 30
2		39	44 42	84 20			10		19	15 56	64 36		
		41	8 62		147 84				20	19 92		167 88	
		43	36 46			232 04			23	7 80			232 24
3		46	22 58	81 96			11		28	52 46	61 88		
		47	44 54		150 06				29	54 34		170 26	
		50	14 60			232 02			32	44 60			232 14
4		52	11 26	83 46			12		36	44 56	63 42		
		53	34 72		148 60				37	47 98		168 72	
		56	3 32			232 06			40	36 70			232 14
5	19	58	51 54	81 32									
	20	0	12 86		150 66								
		2	43 52			231 98							
6		7	26 20	83 08									
		8	49 28		149 12								
		11	18 40			232 20							
7		15	9 74	80 50									
		16	30 24		151 44								
		19	1 68			231 94							
8		21	2 22	82 10									
		22	24 32		149 86								
		24	54 18			231 96							

SEPTEMBER 2

{ 138
Mars
286 }

Transits observed with the Equatorial

East							West						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	4	21 52	157 10			9	2	6	59 06	136 08		
		6	58 62		211 52				9	15 14		232 72	
		10	30 14			368 62			13	7 86			368 80
2		12	48 72	158 52			10		15	24 86	137 46		
		15	27 24		210 10				17	42 32		231 34	
		18	57 34			368 62			21	33 66			368 80
3		21	39 06	156 28			11		25	59 94	135 00		
		24	15 34		212 56				28	14 94		233 61	
		27	47 90			368 84			32	8 55			368 61
4		29	41 34	157 72			12		35	33 38	136 38		
		32	19 06		210 92				37	49 76		232 26	
		35	49 98			368 64			41	42 02			368 64
5	19	38	24 36	155 40			13	2	45	37 40	134 24		
		40	59 76		213 20				47	51 64		234 52	
		44	32 96			368 60			51	46 16			368 76
6		46	36 22	156 96			14	3	0	46 90	135 38		
		49	13 18		211 72				3	2 28		233 28	
		52	44 90			368 68			6	55 56			368 66
7		55	29 70	154 42			15		10	38 16	132 88		
		58	4 12		213 98				12	51 04		235 78	
	20	1	38 10			368 40			16	46 82			368 66
8		3	56 16	156 08			16		19	43 50	134 34		
		6	32 24		212 64				21	57 84		234 42	
		10	4 88			368 72			25	52 26			368 76

September 3

$\left\{\begin{array}{c}143\\ \textit{Mars}\\ 224\end{array}\right\}$

Transits observed with the Equatoreal

East						
Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
1	19	1	21 92	83 16		
		2	45 08		104 72	
		4	29 80			187 88
2		7	36 06	84 64		
		9	0 70		103 22	
		10	43 92			187 86
3		21	12 10	82 12		
		22	34 22		105 76	
		24	19 98			187 88
4		26	51 90	83 84		
		28	15 74		104 11	
		29	59 85			187 95
5		33	51 00	81 22		
		35	12 22		106 50	
		36	58 72			187 72
6		42	58 06	82 96		
		44	21 02		104 96	
		46	5 98			187 92
7		48	35 74	80 68		
		49	56 42		106 84	
		51	43 26			187 52
8		53	41 80	82 42		
		55	4 22		105 28	
		56	49 50			187 70

Note —Intervals were afterwards taken between the stars 224 and 138, in order to connect these observations with those of September 2, morning See last page

SEPTEMBER 4

57
Mars
193

Transits observed with the Equatoreal

East							West						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	18	16	56 94	248 34			9	2	47	38 30	222 70		
		21	5 28		106 06				51	21 00		131 80	
		22	51 34			354 40			53	32 80			354 50
2		26	45 70	249 32			10		58	4 22	223 78		
		30	55 02		105 08			3	1	48 00		130 34	
		32	40 10			354 40			3	58 34			354 12
3		35	17 94	247 56			11		6	42 92	221 38		
		39	25 50		106 64				10	24 30		132 84	
		41	12 14			354 20			12	37 14			354 22
4		42	57·18	248 94			12		14	43 22	223 04		
		47	6 12		105 66				18	26 26		131 26	
		48	51 78			354 60			20	37 52			354 30
5	18	51	6 54	246 66			13	3	23	41 28	220 88		
		55	13 20		108 00				27	22 16		133 40	
		57	1 20			354 66			29	35 56			354 28
6		58	51 74	248 08			14		31	30 76	222 38		
	19	2	59 82		106 32				35	13 14		131 92	
		4	46 14			354 40			37	25 06			354 30
7		6	55 02	246 02			15		40	21 94	220 02		
		11	1 04		108 50				44	1 96		134 12	
		12	49 54			354 52			46	16 08			354 14
8		14	47 22	247 42			16		48	15 16	221 64		
		18	54 64		107 26				51	56 80		132 92	
		20	41 90			354 68			54	9 72			354 56

SEPTEMBER 5

{ 57 *Mars* 193 }

Transits observed with the Equatoreal

EAST							WEST						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	3	40 04				5	3	34	14 94			
				180 90							155 16		
		6	40 94						36	50 10			
					173 26							199 00	
		9	34 20			354 16			40	9 10			354 16
2		11	20 06				6		42	20 18			
				182 80							156 66		
		14	22 86						44	56 84			
					171 66							197·44	
		17	14 52			354 46			48	14 28			354 10
3		19	32 94				7		50	10 82			
				180 12							154 38		
		22	33 06						52	45 20			
					174 16							199 78	
		25	27 22			354 28			56	4 98			354 16
4		27	18 50				8		57	51 12			
				181 72							155 76		
		30	20 22					4	0	26 88			
					172 68							198 38	
		33	12 90			354 40			3	45 26			354 14

SEPTEMBER 6

57
Mars
c

Transits observed with the Equatoreal

EAST

Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
1	19	4	15 70	115 90		
		6	11 60		86 53	
		7	38 13			202 43
2		10	16 70	117 54		
		12	14 24		85 00	
		13	39 24			202 54
3		16	22 58	115 14		
		18	17 72		87 22	
		19	44 94			202 36
4		21	16 52	116 98		
		23	13 50		85 60	
		24	39 10			202 58
5		26	57 30	114 86		
		28	52 16		87 82	
		30	19 98			202 68
6		31	51 10	116 58		
		33	47 68		86 26	
		35	13 94			202 84
7	19	37	28 04	114 18		
		39	22 22		88 16	
		40	50 38			202 34
8		44	41 32	115 82		
		46	37 14		86 66	
		48	3 80			202 48
9		50	5 44	113 56		
		51	59 00		88 92	
		53	27 92			202 48
10		55	16 84	115 24		
		57	12 08		87 28	
		58	39 36			202 52

WEST

Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
11	2	52	58 30	92 20		
		54	30 50		110 52	
		56	21 02			202 72
12		58	2 86	93 52		
		59	36 38		108 80	
	3	1	25 18			202 32
13		3	41 20	91 66		
		5	12 86		110 92	
		7	3 78			202 58
14		9	52 10	93 00		
		11	25 10		109 32	
		13	14 42			202 32
15		16	12 88	91 00		
		17	43 88		111 30	
		19	35 18			202 30
16		21	47 82	92 21		
		23	20 03		110 22	
		25	10 25			202 43

SEPTEMBER 7

14
Mars
c

Transits observed with the Equatoreal

EAST							WEST						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	18	56	42 06	185 68			9	3	40	36 16	158 98		
		59	47 74		151 40				43	15 14		178 00	
	19	2	19 14			337 08			46	13 14			336 98
2		5	8 06	186 92			10		49	6 56	160 56		
		8	14 98		150 12				51	47 12		176 32	
		10	45 10			337 04			54	43 44			336 88
3		14	1 50	184 82			11		56	9 82	158 30		
		17	6 32		152 24				58	48 12		178 64	
		19	38 56			337 06		4	1	46 76			336 94
4		27	48 42	185 84			12		3	42 33	159 81		
		30	54 26		151 26				6	22 14		176 98	
		33	25 52			337 10			9	19 12			336 79
5	19	36	1 18	183 66									
		39	4 84		153 52								
		41	38 36			337 18							
6		46	3 02	185 10									
		49	8 12		152 08								
		51	40 20			337 18							
7		53	56 80	182 95									
		56	59 75		154 11								
		59	33 86			337 06							
8	20	1	42 38	184 46									
		4	46 84		152 88								
		7	19 72			337 34							

SEPTEMBER 8 $\left\{\begin{matrix}14\\ \textit{Mars}\\ c\end{matrix}\right\}$

Transits observed with the Equatoreal

EAST						
Lines	Clock Times			Intervals		
No	h	m	s	s	s	s
1	18	48	53 00			
		50	54 26	121 26		
		54	30 22		215 96	337 22
2		58	25 92			
	19	0	28 56	122 64		
		4	3 06		214 50	337 14
3		6	58 40			
		8	58 94	120 54		
		12	35 84		216 90	337 44
4		14	24 20			
		16	26 06	121 86		
		20	1 54		215 48	337 34
5	19	23	33 22			
		25	32 80	119 58		
		29	10 38		217 58	337 16
6		31	52 54			
		33	53 72	121 18		
		37	29 80		216 08	337 26
7		44	44 62			
		46	43 00	118 38		
		50	21 82		218 82	337 20
8		53	22 54			
		55	22 38	119 84		
		58	59 68		217 30	337 14

SEPTEMBER 9

{*Mars*
57}

Transits observed with the Equatoreal

EAST			WEST					
Runs	Clock Times	Intervals	Runs	Clock Times	Intervals	Runs	Clock Times	Intervals
No	h m s	s	No	h m s	s	No	h m s	s
1	19 23 1 00	79 38	13	2 46 15 12	101 86	25	3 29 56 06	104 10
	24 20 38			47 56 98			31 40 16	
2	26 41 04	77 88	14	49 35 00	99 94	26	33 11 42	101 98
	27 58 92			51 14 94			34 53 40	
3	29 26 18	79 72	15	52 59 52	102 16	27	38 43 18	104 34
	30 45 90			54 41 68			40 27 52	
4	32 58 30	78 08	16	56 9 40	100 42	28	41 57 04	102 72
	34 16 38			57 49 82			43 39 76	
5	36 41 18	80 16	17	3 0 18 94	102 28	29	48 39 80	104 28
	38 1 34			2 1 22			50 24 08	
6	39 24 02	78 26	18	3 42 26	100 84	30	51 56 42	103 08
	40 42 28			5 23 10			53 39 50	
7	42 17 26	80 46	19	3 7 12 12	102 66	31	55 10 50	105 18
	43 37 72			8 54 78			56 55 68	
8	45 8 48	78 76	20	10 53 32	101 28	32	58 20 50	103 34
	46 27 24			12 34 60			4 0 3 84	
9	48 23 24	80 86	21	15 19 08	103 27			
	49 44 10			17 2 35				
10	51 1 20	78 96	22	18 29 30	101 76			
	52 20 16			20 11 06				
11	54 11 18	81 06	23	21 56 00	103 40			
	55 32 24			23 39 40				
12	56 57 14	79 20	24	25 8 54	101 74			
	58 16 34			26 50 28				

September 10 — 1261 *Mars* 57

Transits observed with the Equatoreal

East							West						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	19	11	32 06				9	3	17	4 96			
		13	44 18	132 12					18	53 14	108 18		
		16	7 12		142 94	275 06			21	40 24		167 10	275 28
2		18	19 28				10		23	16 30			
		20	33 20	133 92					25	6 40	110 10		
		22	54 80		141 60	275 52			27	51 90		165 50	275 60
3		25	24 22				11		30	55 16			
		27	35 92	131 70					32	42 96	107 80		
		29	59 60		143 68	275 38			35	30 58		167 62	275 42
4		31	29 84				12		37	46 06			
		33	43 02	133 18					39	35 44	109 38		
		36	5 08		142 06	275 24			42	21 52		166 08	275 46
5	19	38	15 06				13	3	44	58 48			
		40	26 00	130 94					46	45 78	107 30		
		42	50 20		144 20	275 14			49	34 25		168 47	275 77
6		44	33 00				14		52	23 98			
		46	45 60	132 60					54	12 76	108 78		
		49	8 26		142 66	275 26			56	59 62		166 86	275 64
7		53	38 42				15		59	15 96			
		55	48 84	130 42				4	1	2 56	106 60		
		58	13 80		144 96	275 38			3	51 34		168 78	275 38
8	20	2	15 14				16		5	43 12			
		4	26 86	131 72					7	31 26	108 14		
		6	50 38		143 52	275 24			10	18 40		167 14	275 28

September 13

1204
Mars
1261

Transits observed with the Equatoreal.

East							West						
Runs	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s		s	No	h	m	s	s	s	s
1	18	56	41 24	122 02			9	3	56	24 16	96 76		
		58	43 26		52 90				58	0 92		77 94	
		59	36 16			174 92			59	18 86			174 70
2	19	1	19 98	123·70			10	4	1	15 58	98 28		
		3	23 68		51 22				2	53 86		76 26	
		4	14 90			174 92			4	10 12			174 54
3		7	18 32	121 66			11		6	33 64	96·30		
		9	19 98		53 08				8	9 94		78 30	
		10	13 06			174 74			9	28 24			174 60
4		11	57 20	123 36			12		11	26 70	97 86		
		14	0 56		51 64				13	4 56		76 80	
		14	52 20			175 00			14	21 36			174 66
5	19	17	46 10	120 94									
		19	47 04		53 84								
		20	40 88			174 78							
6		22	28 88	122 74									
		24	31 62		52 06								
		25	23 68			174 80							
7		27	29 36	120 70									
		29	30 06		54 10								
		30	24 16			174 80							
8		32	1 36	122·46									
		34	3 82		52 61								
		34	56 43			175 07							

SEPTEMBER 14

1184
Mars
1261

Transits observed with the Equatoreal

EAST						
Runs	Clock Times			Intervals		
No	h	m	s	s	s	s
1	19	53	22 24	93 88		
		54	56 12		115 02	
		56	51 14			208 90
2		58	54 72	95 64		
	20	0	30 36		113 52	
		2	23 88			209 16
3		4	36 24	93·62		
		6	9 86		115 38	
		8	5 24			209 00
4		9	53 20	95 08		
		11	28 28		113 98	
		13	22 26			209 06
5	20	15	43 34	93 02		
		17	16 36		115 92	
		19	12 28			208 94
6		20	56 42	94 64		
		22	31 06		114 32	
		24	25 38			208 96
7		27	4 20	92 54		
		28	36 74		116 44	
		30	33 18			208 98
8		32	1 26	94 00		
		33	35 26		115 04	
		35	30 30			209 04

SEPTEMBER 17 { 1129 *Mars* 1204 }

Transits observed with the Equatoreal

EAST							WEST						
Runs.	Clock Times			Intervals			Runs	Clock Times			Intervals		
No	h	m	s	s	s	s	No	h	m	s	s	s	s
1	18	53	40 80	74 30			9	2	33	2 94	55 12		
		54	55 10		106 64				33	58 06		125 94	
		56	41 74			180 94			36	4 00			181 06
2		58	23 76	75 98			10		38	12 02	56 68		
		59	39 74		104 86				39	8 70		124 42	
	19	1	24 60			180 84			41	13 12			181 10
3		3	47 98	74 08			11		45	28 06	54 48		
		5	2 06		106 90				46	22 54		126 46	
		6	48 96			180 98			48	29 00			180 94
4		8	50 96	75 42			12		50	42 14	55 96		
		10	6 38		105 54				51	38 10		125 08	
		11	51 92			180 96			53	43 18			181 04
5	19	14	17 50	73 72			13	2	57	36 22	54 20		
		15	31 22		107 42				58	30 42		127 02	
		17	18 64			181 14		3	0	37 44			181 22
6		19	3 16	75 28			14		2	19 04	55 72		
		20	18 44		105 82				3	14 76		125 36	
		22	4 26			181 10			5	20 12			181 08
7		24	8 53	73 01			15		9	18 76	53 54		
		25	21 54		107 84				10	12 30		127 38	
		27	9 38			180 85			12	19 68			180 92
8		28	44 84	74 78			16		14	9 72	55 02		
		29	59 62		106 34				15	4 74		125 98	
		31	45 96			181 12			17	10 72			181 00
							17	3	19	27 80	53 25		
									20	21 05		127 71	
									22	28 76			180 96
							18		24	48 48	54 78		
									25	43 26		126 42	
									27	49 68			181 20
							19		30	28 90	52 90		
									31	21 80		128 20	
									33	30 00			181 10
							20		35	18 52	54 30		
									36	12 82		126 70	
									38	19 52			181 00

SEPTEMBER 4 {138 / 224}

Transits observed with the Equatoreal in order to connect the Evening Observations of September 3 with the Morning Observations of September 2

Runs	EAST			
	Clock Times			Intervals
No	h	m	s	s
1	19	36	42 66	
		40	0 44	197 78
2		41	46 24	
		45	4 02	197 78
3		46	49 00	
		50	6 92	197 92
4		52	45 32	
		56	3 08	197 76
5		57	34 04	
	20	0	51 90	197 86

SECTION IV.

Determination of the Solar Parallax.

CONSTANTS for the Observatory near Montego Bay, Jamaica —

	°	′	′
Geographical Colatitude	71	35	9 2
Angle of the Vertical		6	59 0
Geocentric Colatitude	71	42	8 2
Log r (corrected for elevation)	9 9998914		
	h	m	s
Longitude, West of Greenwich	5	11	10

FOR REFRACTION —

	s
Mean Evening value of f	3 487
Mean Morning value of f	3 490
Mean value of f adopted	3 49

FOR INSTRUMENTAL ERROR —

	s	
Mean value of $(i+u \cos \gamma)$	$-6\ 6$	West
	$+6\ 6$	East

THE CHANGE OF CLOCK RATE was always small and highly irregular, it must therefore be neglected, except when determined from the observations themselves

General Table, showing the work done

Day		Stars compared with Mars, M, in order of R A	Number of Transits E	W	Remarks
Aug	6	508, M	24	24	Evening very windy
	7	514, M, 586	24	24	
	8	508, M, 619	24	0	
	9	514, M, 619	24	24	Evening very windy
	10	514, M, 619	24	24	
	11	514, M, 565	24	24	
	12	M, 565	32	32	
	14	M, 565	20	32	Evening hazy
	15	463, M, 565	24	24	463 too faint
	16	M, 565, 619	18	24	Evening and morning hazy
	18	377, M	16	28	
	21	377, M, 463	30	36	
	22	377, M, 453	24	30	453 very faint
	24	286, M, 453	18	0	Evening hazy
	25	309, M, 453	24	0	
	28	286, M, 365	36	0	
	29	253, M, 365	24	24	253 too faint
	31	193, M, 286	24	24	Evening windy
Sept	1	193, M, 286	24	12	Morning hazy
	2	138, M, 286	24	24	
	3	143, M, 224	24	0	Evening bad
	4	57, M, 193	24	24	57 is a close double, the preceding star is observed
	5	57, M, 193	12	12	
	6	57, M, *c*	30	18	
	7	14, M, *c*	24	12	
	8	14, M, *c*	24	0	
	9	M, 57	24	40	
	10	1261, M, 57	24	24	Morning definition bad
	13	1204, M, 1261	24	12	
	14	1184, M, 1261	24	0	
	17	1129, M, 1204	24	36	

Combinations for Parallax, and the Comparison Points

COMBINATIONS					COMPARISON POINTS		
No	East		West		Stars Employed	Approx R A	Approx N P D
	Day	Runs	Day	Runs			
						h m s	° ′
1	Aug 6	12	Aug 6	12	508	23 26 35	99 51
2	7	8	7	8	514, 586	28 12	99 45
3	8	8	6	12	508	26 35	99 51
4	8	8	9	8	619	31 22	100 40
5	9	8	9	8	514, 619	29 3	100 22
6	10	8	10	8	514, 619	29 3	100 22
7	11	8	11	8	514, 565	27 49	100 13
8	12	16	12	16	565	28 55	100 22
9	14	10	14	16	565	28 55	100 22
10	15	8	15	8	463, 565	26 43	100 36
11	16	6	16	8	565, 619	30 9	100 31
12	18	8	18	14	377	20 14	100 43
13	21	10	21	12	377, 463	22 22	100 47
14	22	8	22	10	377, 453	22 4	100 56
15	24	6	22	10	453	23 53	101 8
16	25	8	22	10	453	23 53	101 8
17	28	12	29	8	365	19 24	101 50
18	29	8	29	8	253, 365	16 44	101 40
19	31	8	31	8	193, 286	13 23	101 44
20	Sept 1	8	Sept 1	4	193, 286	13 23	101 44
21	2	8	2	8	138, 286	12 15	101 55
22	3	8	2	8	138	9 10	102 18
23	4	8	4	8	57, 193	8 29	102 16
24	5	4	5	4	57, 193	8 29	102 16
25	6	10	6	6	57, *c*	7 14	102 25
26	7	8	7	4	14, *c*	6 7	102 30
27	8	8	7	4	14, *c*	6 7	102 30
28	9	12	9	20	57	5 32	102 36
29	10	8	10	8	1261, 57	23 3 14	102 32
30	13	8	13	4	1204, 1261	22 59 29	102 39
31	14	8	13	4	1261	23 0 56	102 28
32	17	8	17	12	1129, 1204	22 56 31	102 47

No 22 special measures were taken between 138 and 224, and the true interval was found to be 197 815

The Observed Intervals between the Comparison Points and the Centre of Mars, A, or ½ (A+B), and the corresponding Clock Times, all reduced to their Evening and Morning Means

No	East				West			
	Clock Times			Intervals	Clock Times			Intervals
	h	m	s	s	h	m	s	s
1	20	28	15	+ 118 628	2	9	18	+ 116 840
2	19	11	55	+ 20 952	2	9	45	+ 17 882
3	19	26	53	+ 112 933	2	9	18	+ 116 840
4	19	26	53	− 173 245	2	0	49	− 185 830
5	19	25	33	− 42 167	2	0	49	− 46 799
6	20	12	39	− 53 659	2	1	26	− 58 565
7	20	13	14	+ 5 533	2	9	35	− 0 366
8	20	2	36	− 77 241	2	20	49	− 84 524
9	21	7	7	− 122 217	2	13	18	− 129 220
10	19	38	6	− 13 769	2	35	33	− 24 193
11	19	30	9	− 248 488	2	11	0	− 259 332
12	20	53	13	+ 276 810	2	24	10	+ 266 644
13	19	24	56	+ 31 881	2	39	46	+ 16 276
14	20	7	56	+ 4 121	2	48	17	− 11 095
15	20	18	38	− 202 433	2	48	17	− 120 522
16	19	23	20	− 251 999	2	48	17	− 120 522
17	19	10	37	− 149 442	2	30	30	− 228 715
18	19	42	38	− 48 783	2	30	30	− 67 966
19	19	56	35	+ 28 939	3	24	30	+ 7 019
20	19	58	12	− 33 618	2	25	16	− 52 993
21	19	36	44	− 27 760	2	44	51	− 49 136
22	19	30	54	− 105 174	2	44	51	+ 135 220
23	18	50	50	+ 70 551	3	22	34	+ 44 826
24	19	18	29	+ 4 223	3	48	45	− 21 580
25	19	31	47	+ 14 318	3	8	38	− 8 958
26	19	33	15	+ 16 364	3	55	3	− 9 036
27	19	22	18	− 47 959	3	55	3	− 9 036
28	19	40	31	− 79 398	3	21	18	− 102 532
29	19	37	53	− 5 564	3	43	14	− 29 455
30	19	16	40	+ 34 758	4	5	32	+ 9 988
31	20	14	23	− 114 953	4	5	32	− 77 325
32	19	12	37	− 15 924	3	5	59	− 35 863

No 22 the evening interval refers to star 224, the morning interval to star 138

Corrections to be applied to the Intervals for a Difference of One Minute in N P D
$\phi(\Delta+1')-\phi(\Delta)$, *and the Corrections to be applied to the Clock Times*

No	East		West	
	Clock slow	$\phi(\Delta+1')-\phi(\Delta)$	Clock slow	$\phi(\Delta+1')-\phi(\Delta)$
	s	s	s	s
1	+26	−0 0010	+27	+0 0012
2	29	+0 0013	29	+0 0011
3	31	+0 0005	27	+0 0012
4	31	+0 0005	32	+0 0012
5	32	+0 0006	32	+0 0012
6	33	−0 0007	33	+0 0012
7	35	−0 0008	36	+0 0011
8	36	−0 0005	37	+0 0010
9	37	−0 0014	38	+0 0011
10	38	+0 0001	39	+0 0009
11	38	+0 0002	38	+0 0011
12	38	−0 0012	38	+0 0008
13	41	+0 0005	42	+0 0006
14	42	−0 0007	42	+0 0004
15	44	−0 0009	42	+0 0004
16	44	+0 0006	42	+0 0004
17	44	+0 0014	44	+0 0006
18	44	−0 0002	44	+0 0006
19	44	−0 0006	45	−0 0015
20	46	−0 0007	46	+0 0007
21	48	−0 0002	48	+0 0001
22	48	0 0000	48	+0 0001
23	48	+0 0020	48	−0 0018
24	49	+0 0002	49	−0 0046
25	49	−0 0002	49	−0 0008
26	50	−0 0001	51	−0 0067
27	50	+0 0001	51	−0 0067
28	51	−0 0004	52	−0 0025
29	52	−0 0003	53	−0 0056
30	53	+0 0001	54	−0 0156
31	57	−0 0010	54	−0 0156
32	+ 7	+0 0002	+ 8	−0 0017

The Corrected Intervals between the Comparison Points and the Centre of Mars, and the corresponding Greenwich Mean Times

No	East				West			
	G M T			Intervals	G M T			Intervals
	h	m	s	s	h	m	s	s
1	16	36	36	+118 622	22	16	45	+116 848
2	15	16	37	+ 20 972	22	13	18	+ 17 899
3	15	27	38	+112 939	22	16	45	+116 848
4	15	27	38	−173 264	21	56	35	−185 870
5	15	22	24	− 42 177	21	56	35	− 46 817
6	16	5	27	− 53 650	21	53	16	− 58 579
7	16	2	8	+ 5 533	21	57	32	− 0 365
8	15	47	35	− 77 238	22	4	48	− 84 529
9	16	44	6	−122 221	21	49	28	−129 216
10	15	11	24	− 13 770	22	7	44	− 24 198
11	14	59	33	−248 488	21	39	19	−259 329
12	16	14	31	+276 810	21	44	35	+266 645
13	14	34	44	+ 31 886	21	48	24	+ 16 283
14	15	13	43	+ 4 117	21	52	58	− 11 092
15	15	16	33	−202 438	21	52	58	−120 524
16	14	17	28	−251 993	21	52	58	−120 524
17	13	52	59	−149 466	21	7	45	−228 722
18	14	21	0	− 48 783	21	7	45	− 67 966
19	14	27	3	+ 28 936	21	53	45	+ 7 010
20	14	24	45	− 33 625	20	50	46	− 52 985
21	13	59	26	− 27 761	21	6	23	− 49 135
22	13	49	42	+ 92 641	21	6	23	+135 218
23	13	5	48	+ 70 533	21	36	8	+ 44 839
24	13	29	28	+ 4 222	21	58	21	− 21 566
25	13	38	48	+ 14 320	21	14	24	-- 8 952
26	13	36	21	+ 16 365	21	56	48	− 8 976
27	13	21	29	− 47 960	21	56	48	− 8 976
28	13	35	45	− 79 394	21	15	18	−102 512
29	13	29	12	− 5 564	21	33	15	− 29 455
30	12	56	16	+ 34 758	21	43	42	+ 9 972
31	13	49	58	−114 966	21	43	42	− 77 512
32	12	35	44	− 15 924	20	27	49	− 35 861

The Apparent Motion of Mars in Right Ascension, m, and other functions, taken from the "Nautical Almanac"

At Greenwich Mean Noon

Day	m	$\frac{1}{2}\frac{dm}{dt}$	$\frac{1}{6}\frac{d^2m}{dt^2}$	$\bar{m}$	$m-\bar{m}$
	s	s	s	s	s
August 6	+ 2 336	−1 605	−0 001	+0 022	+ 2 314
7	− 0 876	1 605	+0 001	0 022	− 0 898
9	7 278	1 596	0 003	0 021	7 299
10	10 456	1 580	0 006	0 021	10 477
11	13 595	1 559	0 005	0 020	13 615
12	16 705	1 551	0 005	0 020	16 725
14	22 818	1 499	0 008	0 019	22 837
15	25 799	1 481	0 009	0 019	25 818
16	28 727	1 445	0 012	0 018	28 745
18	34 362	1 369	0 012	0 018	34 380
21	42 256	1 250	0 016	0 016	42 272
22	44 707	1 200	0 018	0 016	44 723
23	47 053	1 185	0 018	0 015	47 068
24	49 293	1 095	0 018	0 015	49 308
29	58 676	0 771	0 026	0 012	58 688
31	61 418	0 600	0 028	0 011	61 429
September 1	62 538	0 521	0 028	0 011	62 549
2	63 491	0 430	0 031	0 010	63 501
4	64 833	0 241	0 033	0 009	64 842
5	65 210	0 135	0 035	0 009	65 219
6	65 373	−0 029	0 033	0 008	65 381
7	65 342	+0 059	0 032	0 007	65 349
9	64 703	0 260	0 033	0 006	64 709
10	64 087	0 355	0 032	0 006	64 093
13	61 118	0 619	0 028	0 004	61 122
17	−54 863	+0 931	+0 023	+0 002	−54 865

Evening and Morning Intervals between the Comparison Stars, corrected for Refraction and Instrumental Error

No	EAST			WEST			$D_\omega - D_e$ corrected
	D_e	Correction	D_e corrected	D_ω	Correction	D_ω corrected	
	s	s	s	s	s	s	s
2	176 731	−0 047	176 684	176 434	−0 040	176 394	−0 290
5	277 939	+0 022	277 961	278 061	+0 044	278 105	+0 144
6	278 074	−0 026	278 048	278 010	+0 044	278 054	+0 006
7	131 639	−0 014	131 625	131 688	+0 019	131 707	+0 082
10	265 298	−0 003	265 295	265 243	−0 025	265 218	−0 077
11	146 347	+0 004	146 351	146 366	+0 020	146 386	+0 035
13	255 714	+0 004	255 718	255 745	+0 004	255 749	+0 031
14	218 819	−0 018	218 801	218 854	+0 010	218 864	+0 063
18	321 535	−0 004	321 531	321 498	+0 013	321 511	−0 020
19	231 988	+0 014	232 002	232 025	+0 036	232 061	+0 059
20	232 009	+0 017	232 026	232 205	−0 017	232 188	+0 162
21	368 640	+0 009	368 649	368 711	−0 005	368 706	+0 057
23	354 483	−0 080	354 403	354 303	+0 072	354 375	−0 028
24	354 325	−0 008	354 317	354 140	+0 184	354 324	+0 007
25	202 525	+0 004	202 529	202 445	+0 018	202 463	−0 066
26	337 130	+0 003	337 133	336 898	+0 208	337 106	−0 027
27	337 238	−0 003	337 235	336 898	+0 208	337 106	−0 129
29	275 278	−0 002	275 276	275 479	−0 045	275 434	+0 158
30	174 879	−0 002	174 877	174 625	+0 343	174 968	+0 091
32	180 991	+0 001	180 992	181 052	−0 010	181 042	+0 050

The Evening and Morning Epochs, and Coefficients of Solar Parallax, P, the observed displacement of Mars in R A (corrected) between the Epochs, and the adopted tabular motion of Mars in R A between the same Epochs

No	East		Observed displacement of *Mars*	Tabular motion of *Mars*	West	
	Epoch (G M T)	P			Epoch (G M T)	P
	d	−	s	s	d	+
1	August 6 69208	0 1071	+ 1 774	− 0 068	August 6 92830	0 0982
2	7 63654	0 1373	+ 3 041	− 0 984	7 92590	0 0993
3	8 64419	0 1336	− 3 909	+ 5 867	6 92830	0 0982
4	8 64419	0 1336	+ 12 606	− 10 399	9 91429	0 0962
5	9 64056	0 1349	+ 4 617	− 2 676	9 91429	0 0962
6	10 67045	0 1174	+ 4 928	− 3 132	10 91199	0 0973
7	11 66815	0 1179	+ 5 901	− 3 968	11 91495	0 1026
8	12 65804	0 1234	+ 7 291	− 5 020	12 92000	0 1092
9	14 69729	0 0916	+ 6 995	− 5 351	14 90935	0 1069
10	15 63292	0 1351	+ 10 433	− 8 126	15 92204	0 1191
11	16 62469	0 1382	+ 10 780	− 8 587	16 90230	0 1074
12	18 67675	0 1008	+ 10 165	− 8 372	18 90596	0 1158
13	21 60745	0 1431	+ 15 606	− 13 293	21 90861	0 1264
14	22 63453	0 1251	+ 15 208	− 12 906	22 91178	0 1313
15	24 63649	0 1201	− 81 914	+ 84 264	22 91178	0 1313
16	25 59546	0 1445	− 131 469	+ 133 720	22 91178	0 1313
17	28 57846	0 1489	+ 79 256	− 76 847	29 88038	0 1285
18	29 59792	0 1364	+ 19 187	− 16 887	29 88038	0 1285
19	31 60212	0 1295	+ 21 931	− 19 323	31 91233	0 1524
20	Sept 1 60052	0 1283	+ 19 329	− 16 961	Sept 1 86859	0 1283
21	2 58294	0 1378	+ 21 368	− 18 999	2 87943	0 1375
22	3 57618	0 1400	− 42 577	+ 44 880	2 87943	0 1375
23	4 54570	0 1546	+ 25 689	− 23 083	4 90009	0 1532
24	5 56213	0 1444	+ 25 788	− 23 097	5 91552	0 1615
25	6 56861	0 1379	+ 23 271	− 20 682	6 88500	0 1492
26	7 56691	0 1363	+ 25 341	− 22 662	7 91444	0 1630
27	8 55659	0 1404	− 38 973	+ 41 774	7 91444	0 1630
28	9 56649	0 1318	+ 23 118	− 20 513	9 88562	0 1530
29	10 56194	0 1320	+ 23 881	− 21 353	10 89809	0 1595
30	13 53907	0 1387	+ 24 798	− 22 059	13 90535	0 1633
31	14 57637	0 1096	− 37 454	+ 39 894	13 90535	0 1633
32	17 52481	0 1365	+ 19 930	− 17 555	17 85265	0 1456

Equations for the Determination of the Solar Parallax

(See next page)

No	Equations of Condition	Weight	π''	Error of π''
			$''$	$''$
1	$0\ 2053\ \pi'' = 1\ 706+0\ 236\ \delta m_{6}$	30	8 31	−0 49
2	$0\ 2366\ \pi'' = 2\ 057+0\ 289\ \delta m_{7}$	27	8 69	−0 11
3	$0\ 2318\ \pi'' = 1\ 958-1\ 716\ \delta m_{7}$	24	8 45	−0 35
4	$0\ 2298\ \pi'' = 2\ 207+1\ 270\ \delta m_{9}$	20	9 60	+0 80
5	$0\ 2311\ \pi'' = 1\ 941+0\ 274\ \delta m_{9}$	27	8 40	−0 40
6	$0\ 2147\ \pi'' = 1\ 796+0\ 242\ \delta m_{10}$	27	8 37	−0 43
7	$0\ 2205\ \pi'' = 1\ 933+0\ 247\ \delta m_{11}$	27	8 77	- 0 03
8	$0\ 2326\ \pi'' = 2\ 271+0\ 262\ \delta m_{12}$	40	9 76	+0 96
9	$0\ 1985\ \pi'' = 1\ 644+0\ 212\ \delta m_{14}$	31	8 28	−0 52
10	$0\ 2542\ \pi'' = 2\ 307+0\ 289\ \delta m_{15}$	27	9 08	+0 28
11	$0\ 2456\ \pi'' = 2\ 193+0\ 278\ \delta m_{16}$	23	8 93	+0 13
12	$0\ 2166\ \pi'' = 1\ 793+0\ 229\ \delta m_{18}$	25	8 28	−0 52
13	$0\ 2695\ \pi'' = 2\ 313+0\ 301\ \delta m_{21}$	36	8 59	−0 21
14	$0\ 2564\ \pi'' = 2\ 302+0\ 277\ \delta m_{22}$	30	8 98	+0 18
15	$0\ 2514\ \pi'' = 2\ 350-1\ 725\ \delta m_{23}$	19	9 35	+0 55
16	$0\ 2758\ \pi'' = 2\ 251-2\ 684\ \delta m_{24}$	22	8 16	−0 64
17	$0\ 2774\ \pi'' = 2\ 409+1\ 302\ \delta m_{29}$	24	8 69	−0 11
18	$0\ 2649\ \pi'' = 2\ 300+0\ 282\ \delta m_{29}$	27	8 68	−0 12
19	$0\ 2819\ \pi'' = 2\ 608+0\ 310\ \delta m_{31}$	27	9 25	+0 45
20	$0\ 2566\ \pi'' = 2\ 368+0\ 268\ \delta m_{1}$	18	9 23	+0 43
21	$0\ 2753\ \pi'' = 2\ 369+0\ 296\ \delta m_{2}$	27	8 61	−0 19
22	$0\ 2775\ \pi'' = 2\ 303-0\ 697\ \delta m_{2}$	20	8 30	−0 50
23	$0\ 3078\ \pi'' = 2\ 606+0\ 354\ \delta m_{4}$	27	8 47	−0 33
24	$0\ 3059\ \pi'' = 2\ 691+0\ 353\ \delta m_{5}$	13	8 80	0 00
25	$0\ 2871\ \pi'' = 2\ 589+0\ 316\ \delta m_{6}$	25	9 02	+0 22
26	$0\ 2993\ \pi'' = 2\ 679+0\ 348\ \delta m_{7}$	18	8 95	+0 15
27	$0\ 3034\ \pi'' = 2\ 801-0\ 642\ \delta m_{7}$	18	9 23	+0 43
28	$0\ 2848\ \pi'' = 2\ 605+0\ 319\ \delta m_{9}$	38	9 15	+0 35
29	$0\ 2915\ \pi'' = 2\ 528+0\ 336\ \delta m_{10}$	27	8 67	−0 13
30	$0\ 3020\ \pi'' = 2\ 739+0\ 366\ \delta m_{13}$	18	9 07	+0 27
31	$0\ 2729\ \pi'' = 2\ 440-0\ 671\ \delta m_{13}$	13	8 94	+0 14
32	$0\ 2821\ \pi'' = 2\ 375+0\ 328\ \delta m_{17}$	32	8 42	−0 38

In the last page, δm_x is the correction to be applied to m_x given in page 66, the suffixes of δm refer to the days of the month It is proposed to obtain these corrections from the meridional observations of the planet at Greenwich

The weights were obtained in the following manner Let e be the probable error in the time of transit across the mean wire of a star, or of a limb of *Mars* Then, when there is only one comparison star, the probable error of the interval is $e\sqrt{2}$, and if n_ϵ intervals were observed in the evening, and if n_ω intervals were observed in the morning, the probable error of $(P_\omega - P_\epsilon)\ \pi''$ is

$$e\sqrt{2}\sqrt{\frac{1}{n_\epsilon}+\frac{1}{n_\omega}},$$

and the theoretical weight is proportional to

$$\frac{n_\epsilon n_\omega}{2\,(n_\epsilon+n_\omega)}$$

But when there are two comparison stars the probable error of the interval from the mean of the two stars is $e\sqrt{\frac{3}{2}}$, and in this case the theoretical weight is proportional to

$$\frac{2}{3}\,\frac{n_\epsilon n_\omega}{(n_\epsilon+n_\omega)}$$

The numbers n_ϵ and n_ω were taken from page 62, and the weights were multiplied by 10 in order to avoid decimal places.

The column headed π'' contains the separate solutions of the equations, neglecting δm_x, and without regard to weight

By applying the weights we get 8″ 80 as the value of the Solar Parallax, and then the numbers in the last column are obtained by subtracting 8″ 80 from the different values of π''

Now if the observations are divided into two classes, so that the first class contains those which were made with two comparison stars, and the second class those which were made with only one comparison star, it will be found that the mean value of (error × weight)^2 is 51 4 for the first class and 253 4 for the second Consequently the weight due to the quality of the first method is to the weight due to the quality of the second method as 5 is to 1 nearly But as this result is greatly affected by the observations made on one night, namely August 12, it will be advisable to reduce this ratio, and we shall assume these weights to be as 4 is to 1 Hence it is necessary to multiply the former weights of the first-class equations by 4

The resulting Solar Parallax is

$$8''789,$$

with a probable error of 0″ 060

Jamaica, 1877, *November* 22

III *Observations of Mars, at Madeira, in August and September* 1877

By N E Green, Esq

◆

The Instrument —These observations were made with a reflecting telescope of the Newtonian form, furnished with a 13-inch speculum, figured by Mr Geo. With, of Hereford The frame was mounted as an altazimuth, open at the sides, thus giving free access to the external air The powers employed were from 200 to 400, the one most frequently used giving an enlargement of 250 diameters The instrument was first erected at an elevation of about 1,200 feet, and afterwards moved to a situation 2,200 feet above the sea. Particulars of its performance, and the opportunities for observation afforded by the climate and atmosphere of Madeira, may be seen in the *Monthly Notices*, vol. xxxviii., No 1, November 1877

The Drawings —The twelve views which accompany this paper were selected from forty-one drawings, all of which were made direct from the telescope; the endeavour in the selection being to give a view of the planet at intervals of about two hours. The longitudes have been kindly supplied by Mr. Albert Marth An earnest effort has been made to preserve the truth and character of the original drawings and to make the lithographic print a facsimile of those produced at Madeira. It may be remarked with regard to drawings of the planets generally, that they are necessarily exaggerations. When the eye has been taxed to the utmost to observe the form of some delicate marking, any shade which the hand could apply to a drawing, and which could be trusted to remain as a memento of the observation, would be far beyond the strength of the reality. But the value of the representation need not therefore be unduly depreciated; for if a proportionate amount of force be given to all the details, it is still useful as expressing the general character of the object, and valuable as exhibiting a fair relation between its several parts

A critical examination of the various views, and especially those which more immediately follow each other, will discover some discrepancies of form or position in the markings, but it was thought better to retain these errors, pointing out where they occur, than to correct them, especially as some valuable hints with regard to astronomical drawings generally may be derived from these imperfect operations of the eye and hand.

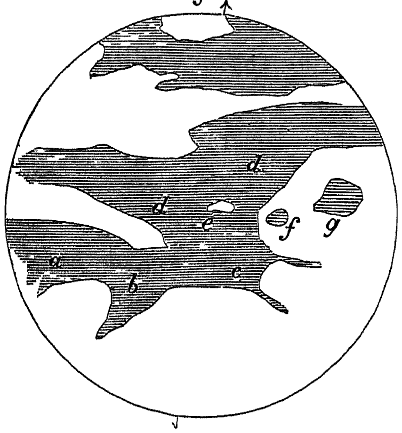
NOMENCLATURE.—In the index to these drawings, and in references to them in this paper, the names employed are those used to designate the various markings in the maps of the planet published by Mr PROCTOR from a series of drawings by Mr. DAWES. To these a few other names have been added where the forms appear to have been observed for the first time.

It has also been considered desirable that the name of the same observer should not be given to several markings, but that each definite form should have some name to distinguish it from all others; a change is therefore made in the name of the Lockyer Sea, which in the index bears the name of Dr. TERBY, &c.

Figures 1, 2, and 3—These drawings, the product of the night of September 1, were made under the most favourable atmospheric conditions; definition, good at the first, became magnificent as the night advanced, and it would be difficult to exaggerate the keen map-like appearance of the planet on this occasion The views differ considerably from the previously accepted forms of this portion of the Martial surface, but they are fairly sustained by drawings made at Greenwich by Mr CHRISTIE and Mr. MAUNDER, by those of Mr BRETT at the Land's End, by the observations and maps of Professor SCHIAPARELLI at Milan, and also by the drawings of Dr TERBY at Louvain, and Professor TROUVELOT at Cambridge, U S

In the first of these drawings part of the Kaiser Sea, *q*, is just disappearing at the western limb. Dawes Forked Bay, the "*a*" of BEER and MADLER, from which their longitudes were reckoned, has just passed the meridian, and is followed by a long bay tending N.W, called Burton Bay in the index To the east of Burton Bay there is a broader form extending towards the north-east and terminating in a point, and it may be observed that in Fig. 2 this same mark is represented as having a square termination, called Christie Bay in the index, the alteration of form being due to the better definition produced by advance towards the centre of the disk It may be remarked in connection with this difference of form in these two drawings, that whenever an elongated dark form was imperfectly seen, there was a great tendency to prolong its shape into a point or a line. It is possible that this tendency of the eye to see, or suppose that it sees, a continuation to an indefinite shape, may account to some extent for the attenuated lines in some of Mr. DAWES' views of the planet, and also for the remarkable dark canals, extending into the lighter portion of the surface, so strongly depicted in the maps of Professor SCHIAPARELLI These remarks acquire peculiar force when taken in connection with the effort to see and to draw the surroundings of the Lockyer Sea (now Terby Sea, *g*) This sea is usually represented as united to the De la Rue Ocean, *d*, by a dark canal, and it had exactly this appearance in momentary glimpses during the earlier portion of the night on which these three drawings were made; but as definition improved, this apparent strip contracted into a definite point, *f*, which was seen clearly and sharply separate from the surrounding markings It is interesting to state that in a Greenwich drawing, by Mr CHRISTIE, August 30, 12^h 15, this dark point* appears as a bay in connection with the De la Rue Ocean, and thus it would doubtless have been represented in the Madeira series but for the

Fig. 2.



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* *See* the remarks of Dr Dreyer, *post*, p 136

exceptionally fine definition of the night of September 1. In a drawing by Professor Schiaparelli this dark spot is clearly separated from the De la Rue Ocean excepting on the south, where it is joined to the ocean by a short dark canal. As this dark spot has been observed for the first time in the opposition of 1877, and is therefore without a name, we would suggest Lake Schiaparilli as an appropriate designation. Should this spot be again visible during the opposition of 1879, it will serve admirably for a recalculation of the axial rotation, as it was observed at Madeira to be exactly at the centre of the disk on September 1, $14^{h}\cdot20$ G M T. Northwards from this dark spot there may be seen in Figs. 2 and 3 the squarish form we have named Christie Bay, and from each angle a faint tone of shade extends eastward The one nearest to the dark spot Lake Schiaparelli is the only trace that could be observed of what appears in Mr Proctor's maps as Dawes Sea Westward from Lake Schiaparelli may be seen in Figs 2 and 3 a white spot, *e*, this is doubtless the snow island of Mr Proctor's map. It was observed by Mr Maunder, of Greenwich, on October 2, 10^{h} 4, and also by Professor Schiaparelli on more than one occasion, but appeared to him to vary in its brightness To the west of the polar cap there was seen on this evening, at 10^{h} 40, a separate point of light, *w*, Fig 1, which in all probability was snow still resting on elevated ground after it had melted from the lower levels This point shone like a star and could not have been overlooked by a careful observer This light was afterwards seen on September 8, at 12^{h} 30, but it then presented the appearance of two separate points—*see* Fig 12, and on September 10, at 11^{h} 30, a faint line of points was observed concentric with the zone of snow—*see* Fig 11 These alterations of form were in all probability due to perspective, the single point of September 1 appearing as two when less foreshortened, and these still further separated and increased in number as they were seen nearer the central meridian of the disk These points of light were not on any occasion observed on the eastern side of the polar cap, and this circumstance possesses peculiar interest in connection with the existence of snow on the planet For this brilliant appearance of the spots when most to the west of the pole, and their decrease in brilliance when passing the meridian, together with the most significant fact that they were not seen at all on the eastern side, can best be explained by supposing the slopes of the hills that retained the snow to have a south-westerly aspect, they would thus be sheltered from the Sun's rays during the greater part of a revolution, but fully exposed to its light, and therefore better seen, just as they were passing away towards the western limb. A larger drawing of the south pole is given in the centre of the plate, in which dark valleys breaking the outline may be observed; but the brilliant point is not so truly placed as in Fig. 1, where it appears nearer the outline of the disk It is interesting to state that this point of light is most clearly and exactly figured in a drawing by MITCHEL, of Cincinnati, U S., August 30, $4^{h}\cdot55$, 1845, and published by him in the *Sidereal Messenger*. It there occupies the same position on the western limb, and is doubtless connected with some special local configuration It has been named in the index Mitchel Mount, in memory of that ardent lover of astronomy. Mr. BRETT was observing *Mars* at the Land's End on the night of September 1, and describes this light near the pole as an "auxiliary patch." There is a strange resemblance to the head of an animal in the forms to the east of the De la Rue Ocean. This would doubtless disappear under more favourable optical conditions; the hard lines would then be found to be indented and broken, and the crudities of form disappear as truth advanced. The whole of these parts in Fig. 3 were drawn a little too high on the disk This is especially the case with the Terby Sea (the Occulus of the Italians); it should be fully its diameter further north.

Figure 4—The principal interest in this drawing is the evidence that it affords of the presence of cloud on the planet, breaking the continuity of the outline of the De la Rue Ocean, *d*, and in other places obscuring the forms The eastern edge of this ocean was drawn at Madeira sixteen times, and on each occasion was found to be clearly and even sharply defined, but on September 29 it appeared as in Fig. 4, broken by a mass of cloud, a second mass lying more to the south and within the outline of the sea These obscurations of portions of the planet's surface are by no means unusual. In the series of drawings made in 1864 by Mr. LOCKYER a portion of the Dawes Ocean to the west of the Kaiser Sea is evidently hidden by cloud, and a similar appearance at the same spot was observed both by Mr. CHRISTIE and Mr. MAUNDER, at Greenwich, on October 16, 1877

Figure 5—The general forms of this view are thoroughly sustained in a drawing by Mr. MAUNDER, of Greenwich, on September 26, 10^{h} 29, and

the agreement of the details is so exact, that together they may be taken to establish the truth of the markings of this portion of the planet's surface, at least at the date on which the drawings were made. The Terby Sea or Occulus appears followed by and connected with a small dark spot tending north-east. This small spot was observed at Madeira, on August 23, to be surrounded with light In the index this spot, *i*, is named Bessel Lake

Above this dark spot, in a direction towards the south pole, is a definite dark line, and below it, towards the north-east, there is a faint line of shade, and as both these marks lie nearly in the direction of what was named by Mr Proctor Bessel Inlet, it is highly probable they gave rise to this snake-like form in the drawings of Mr Dawes Towards the north pole in this drawing may be observed a series of delicate shades having a meridional direction, and as these lines do not belong to the permanent markings of the planet, they may be placed amongst the atmospheric effects, and possibly indicate the flow of currents of cold air from the pole towards the equator.

Fig 6.

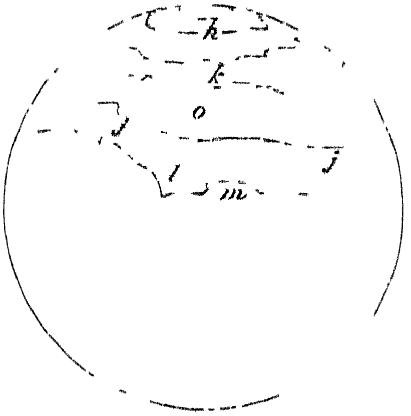

Figure 6—This view introduces a peculiar series of zone-like markings which extend from longitude 130° to 250° and only cease at the Kaiser Sea The forces which produce these alternate bands of land and water, if such they be, offer a field of conjecture to those inclined to theorise on such matters The most prominent dark band in the drawing is that known as Maraldi Sea, *j*; Joynson Sea, *h*, being next the pole. Between these there is a sea, *k*, which may be observed in this and following two drawings, which does not

appear to have been figured before It is clearly seen in a drawing by Mr MAUNDER on September 21, 10h·54, who also has this note attached "The narrow sea round the polar snow seemed quite separated from the faint sea near it" In the index to these drawings it bears Mr MAUNDER's name. In connection with Fig. 6 there is an interesting note on the original drawing to this effect that when the planet was partly obscured by thin cloud, the contrast between the orange tone of the central portions of the disk and the bluish light surrounding the limb became very evident, and it may be remarked in favour of the transparency of the Madeira air, that it required thin cloud to draw attention to an effect of contrast which was clearly seen and frequently observed under average atmospheric conditions in England The most prominent mark on this portion of the planet's surface is a dark angle of the Maraldi Sea, *l*, which there forms a deep bay extending towards the equator This bay is most admirably drawn in a view of *Mars* by Professor TROUVELOT, U S, on September 30, 10h 10 C M T., 1877, and in the index it is called Trouvelot Bay There is in this and the following drawing a projection of the light portion of the disk into the northern edge of the Maraldi Sea, lettered *m* in the index This was seen by Captain NOBLE and carefully drawn by him on September 21, 11h·25. The land marked *o* in the index, between Maunder's Sea and the sea of Maraldi, has been named Webbs Land, in exchange for the narrow and somewhat doubtful isthmus called Webbs Land by Dr Terby

Figures 7 and 8 —In these drawings the long dark form known as Maraldi Sea comes to an end, having extended through more than 100° of longitude. At its north-eastern end a faint winding shade, *n*, may be seen extending towards the north pole, this occurs very nearly in the position of Huggins Inlet and was the only form observed that could have been connected with that shape in the drawings of Mr DAWES. Fig. 7 shows clearly the commencement of Hooke Sea, *p*, and the bearing of its western end on that of Maraldi, *j*. In this drawing may also be observed the continuation of Maunder's Sea, its extension towards the south pole being shown in Fig 8 There is an interesting observation in connection with the polar cap in these two drawings In Fig 7 it is small and undefined, whereas in the next view, drawn less than two hours afterwards, it recovers its size and clearness of outline. The dark marks surrounding the pole seem also to be similarly affected—faint and undefined in the earlier drawing, but dark and decisive in the later one Both Mr Maunder, at Greenwich, and Mr Brett, at the Land's End, noticed the reduced and indefinite appearance of the south pole about this date, this appearance of the polar cap was also observed by Dr Terby, at Louvain, on September 17, and on this occasion he remarks there was an increase of brightness between 8h 30 and 10h 15, from the Madeira drawings it would appear that a similar clearing up of the Martial atmosphere occurred on the night of September 18 It may be objected by some, that the reason for the better definition of the pole in Fig 8 is to be found in the later hour and greater elevation of the planet; but the notes on the original drawing do not support this view, for the definition, at least as far as it was affected by terrestrial circumstances, had rather deteriorated, the air being more steady at the earlier hour

Figure 9—This drawing introduces the grandest mark on the surface of *Mars*, the Kaiser Sea, *q*, which is well within the eastern limb Lockyer Land, *r*, the large orange patch between the Kaiser Sea and the south pole, becomes also a most important feature. It is difficult to account for the alterations in the form of this land in the three following drawings, yet they seem to be consistent with each other. It gradually decreases in size to Fig 12; but why it should occupy a larger area in Fig 9 than in Fig 11, where it is on the meridian, is somewhat puzzling The supposition that it is of an oval form, lying obliquely to the equator, will explain some of these changes, for in this case it would come on the disk with its longest axis presented to the eye, whereas, as it passed off towards the west, its shorter axis would in turn be visible

Figure 10—The forms represented in this view are fully supported by a drawing made by Mr Maunder, at Greenwich, on October 15, 7h 12, 1877 It is also in close agreement with the view of this phase in the grand series by Mr Lockyer, published in the Society's *Memoirs* in 1862, and all its larger features are evident in a map-like drawing by Professor Schiaparelli, but in his view the light portions of the planet's disk are crossed by various dark canals, which certainly were invisible at Madeira In justice to the learned and exact professor, it should be remarked that many of these dark canals were only visible to him during the months of February and March 1878 We are therefore presented with the following alternative: either that

vast physical changes had occurred in the atmosphere or on the surface of the planet between September 1877 and the early part of 1878, or that optical effects to which allusion has been already made had some influence in producing these appearances

Figure 11 —This drawing was made only two hours after that of the previous figure, but definition had in that short interval become superb. The eye-piece employed was an achromatic by Mr BROWNING, made especially for these drawings of *Mars*, and finished with the greatest care, its power giving an enlargement of 400 diameters The atmospheric condition of *Mars* seemed also to be most favourable to the exhibition of minute forms and the most delicate tints of shading and colour The edge of the polar snowcap was seen to be indented by several projections of the darker surrounding tone, and even in its general mass several delicate changes of tint were observed, indicating ridges and roughness on its surface, below it a series of minute points of light were clearly visible, being the result of the separation of those brighter points of light which had been frequently seen since September 1 Towards the western limb a junction was observed between Zollner Sea, and Hooke Sea, and to the west of the Kaiser Sea a most delicate shading, *s*, was visible somewhat in the position of the form known as Main Sea This shading was faintly seen on the 15th—*see* Fig 9—and appears in drawings by Mr PRATT, of Brighton, and in those by Professor SCHIAPARELLI On the eastern side of the Kaiser Sea, and in the angle formed by it and Herschel II. Strait, a bay or sea was observed nearly separate from the Kaiser Sea Immediately to the east of this dark sea there is a brilliant angle of light, *l*, on that part of the Dawes Continent which lies nearest the equator This part was most carefully observed and drawn by Mr BANKS, at Ealing, in 1862, whose views of the planet were afterwards published in the *Astronomical Register*, to this kind and most amiable friend the writer owes his introduction to the noble science of astronomy, and in the index it is named Cape Banks, in grateful remembrance of his friendship and assistance The most faint form observed on this occasion was the triangular space of light, *u*, which is seen half way between the Kaiser Sea and Lockyer Land; but as this figures very clearly in a drawing by Mr HIRST, at Sydney, August 3, $10^{h}\cdot30$, there can be no doubt of its existence It is also visible in a highly finished and accurate

drawing by Professor TROUVELOT, Cambridge, U S, September 16, 9^h 40, Cambridge mean time The singularly exact agreement between the details of the Professor's drawing of this date and the No 11 of this series affords the strongest proof of the truth of this representation of the planet's surface

Figure 12 —On this occasion the orange colour of the Martial continents was particularly evident, together with great refinement in details The points of light called Mitchel Mountains, to the west of the polar snow, have already received a notice These are located near longitudes 270° and 280°, and no small amount of interest will attend a search for them on some future favourable occasion

Of all these views, that represented in Fig 11 was without comparison the grandest obtained at Madeira This drawing also, of all the series, most effectually recalls the impression received at the telescope, this sight of *Mars* was felt at the time to be a rich reward for every effort, and will remain, while memory lasts, a constant delight and satisfaction.

GENERAL REMARKS

AXIS —In No 1 of the outlines which serve as an index to the drawings an attempt has been made to give the direction of the axis of rotation This cannot claim in any way to be the result of calculation, but simply that direction which best accords with the movement of the markings across the surface of the planet's disk The markings seemed always to come on the disk lower towards the east, and to leave it higher on the west, than was consistent with an axis concentric with the polar cap It is also Mr PROCTOR's opinion, from various observations, that the axis of rotation lies just within the eastern edge of the south polar snow as it appeared in September 1877

ATMOSPHERE —The principal evidence of atmosphere is the constant fading of the markings and colours as they approach the limb, and it has been remarked by Captain NOBLE that this fading was more evident on the western than on the eastern limb, indicating that sunrise on *Mars* was generally more clear than sunset The most decisive evidence of this atmospheric ring within the limb of the planet was observed on September 20, when the bluish white of this portion was most strongly contrasted with the orange tone of the centre, a contrast which was much increased when observed through thin passing clouds The northern hemisphere was singularly free from markings, and although on one or two favourable occasions the stronger darks could be traced into it, the general effect was that of atmosphere rather than of surface details The most remarkable appearance in this hemisphere is shown in Fig 5, where the meridional lines occur to which reference has already been made It is far from improbable that the north polar region, which in the opposition of 1877 lay beyond the visible portion of the limb, was not only in darkness but covered by cloud, from which the snow of a future opposition might be condensed and deposited

CLOUDS —The clouds of *Mars* are evidently much less dense than those of the Earth, indeed so much so that no cloud proper can be said to exist in the equatoreal regions This has been clearly argued by Mr BRETT, though he has been led to consider the snowcaps as cloud formations, a theory which appears to be strongly opposed by the behaviour of those caps, and especially by the sharp definite and fixed points of light left behind by their contraction, which have been seen after many years to occupy the same places, and which points during the opposition of 1877 preserved a fair relative position amongst each other; this at least is not how clouds usually behave But though of cloud proper there seems but little evidence, of vapour sufficiently like cloud to hide, and that completely, portions of the darkest markings, there is evidence in abundance In Fig 4 the outline of the De la Rue Ocean is not only obscured, but a portion of it hidden, by cloud In drawings 7 and 8 there is evidence of the clearing up of the zone about the south pole, the indistinctness of the polar patch about this time having been noticed by Mr MAUNDER, Mr BRETT, and Dr TERBY. In the Greenwich drawings of 1877, and those in 1862 by Mr LOCKYER, parts of Dawes Ocean were hidden occasionally by a light which was not always observed in that position In addition to these facts may be mentioned the occasional appearance of white masses, almost rivalling the pole in brightness, which have been observed on the limb near the northern pole, and especially on the eastern side, one of these is figured in a drawing by the writer, published in the *Astronomical Register*, vol III, March 1865. These masses of light were observed upon the limb only, and did not advance within it; they were not therefore attached to the surface, and the only solution we can propose is that they were volumes of cloud or mist, which were dissipated by the rising Sun. Such effects of the Sun's rays frequently occur in our own climate, especially in mountain districts.

SNOW.—The argument in favour of the polar cap being composed of snow has in great part been anticipated in the remarks upon Fig. 1. But there is further evidence if it be required. In the drawing of *Mars*, April 20, 1856, published by Mr. DE LA RUE, the whole of the continent to the south of of the Kaiser Sea is evidently under snow; for at this time the south pole was out of sight, and the form of the white portion is just that of Lockyer Land seen foreshortened. This appearance is also clearly shown in Figs. 3 and 4 of a series of drawings by the author of this paper, published in the *Astronomical Register* in 1873; in these also the south polar cap is out of sight, but the snow extends in an angular form exactly over the position of Lockyer Land. There is also a strong indication of the presence of snow on the line of light that forms the edge of Beer Continent, *v*, near the equator; and it is no extravagant supposition to consider that this continent may be bounded by mountain ranges of great height, as the continents of North and South America, on the western coast, by the Andes. These lines of light are not confined to the edge of Beer Continent, but may be seen on other portions of the surface of the planet, such as Kepler Land to the south of Terby Sea, Hind Peninsula, *x*, and the so-called snow island of Mr. DAWES.

COLOUR.—An attempt has been made to illustrate this subject in the drawings. The general tone of the central portions of the disk may be described as a warm yellow, heightening into orange on some of the continents, especially on Lockyer Land and Beer and Herschel Continents. The darker portions, supposed to be water, were a greenish grey, partly due to contrast with the orange; but it varied so much in depth and tone, that much of its colour must have been the result of local changes. It was very interesting to observe the delicate alterations in depth of the darker portions, and if depth of tone means depth of water, deep indeed must be some parts of the Sea of Kaiser. The Terby Sea, or Occulus, was a very dark spot, much darker in proportion than is represented in the drawings, it always caught the eye before any other mark, especially when near the meridian The atmospheric ring, which generally surrounded the interior edge of the disk, has been already described as a bluish white, but this did not attract so much attention at Madeira as in the English observations

The thanks of the Author are heartily given to those who have so kindly placed their drawings at his service, for examination and comparison with his own These are first due to Sir GEORGE AIRY, for his kindness in allowing the use of the Greenwich series by Mr CHRISTIE and Mr MAUNDER, and to Mr CHRISTIE, for his earnest co-operation in the effort to procure other views or information connected with the subject The drawings of Mr. BRETT have been most serviceable in confirming and supporting the truth of the general forms, and those by Dr TERBY, Capt NOBLE, and Mr PRATT have greatly assisted the investigation. To Professor SCHIAPARELLI the writer is particularly indebted for his prompt reply to the request for drawings, and also to Professor TROUVELOT, between whose views of the planet and those made at Madeira there exists such serviceable agreement

The thanks of the Author would be most incomplete without a reference to the valuable assistance received from friends at Madeira, especially from Mr. WM HINTON and family, by whose efficient help the observations were greatly facilitated, while the mind and body of the artist were refreshed and strengthened by constant sympathy and kindness. To Mr CHARLES R. BLANDY also most sincere thanks are due, for the great interest shown by him in telescopic matters, every help in his power being most generously and kindly given

One decisive advantage has been gained by this united effort to produce drawings of the planet. There is an evident advance in the knowledge of fixed markings, and the doubts and difficulties which in former years have attended the effort to harmonise conflicting views have in a great measure disappeared—a fairly consistent *Mars* being the product of the memorable opposition of 1877.

ADDENDA

Since the Memoir on *Mars* was written, the Earl of Ross has kindly forwarded a copy of Dr Dreyer's views of the planet, made in 1877, at his Lordship's Observatory at Parsonstown The drawings are accompanied with a few remarks upon the definition of the surface markings

There is a fair agreement between the drawings by Dr. Dreyer and those produced at Madeira, especially between No 6 of the Parsonstown series, September 16, $10^h 55^m$, and No 8 of the Madeira views, drawn on September 18, $11^h 45^m$

Amongst the remarks there is one of peculiar interest, showing that similar optical illusions may present themselves to observers separated by great distances, and using instruments of very different light-grasping powers —

Dr. Dreyer, observing with the three-foot mirror, writes "Lockyer Sea was always seen of a very regular shape, slightly oval east and west. It appeared to be joined to the De la Rue Sea by an extremely faint and diffused band, but this was considered rather doubtful" This is exactly the character of definition to which allusion is made at page 125 of this Memoir, and refers to the same portion of the planet's surface Dr Dreyer would have been justified in connecting the Lockyer Sea with the De la Rue Ocean by a faint band in his drawings, although he might have added a note expressing his doubt as to the exactness of the observation , and, had it not been for the singularly good definition of the night of September 1, at Madeira, this series would have exhibited the imaginary faint band also

But the small sea called "Schiaparelli" receives a confirmation from Parsonstown In a letter to the author, Dr Dreyer remarks: "On my drawing No 9 there is a small spot nearly midway between Lockyer Sea and De la Rue Sea, and when I read your note in the *Monthly Notices* for December 1877, I thought at once that I had seen and shown on Fig 9 what you call a very small sea" The special interest connected with these statements is this that, both at Parsonstown and Madeira, each observer sees at one time a faint band, connecting the Lockyer Sea with the De la Rue Ocean, which band resolves itself, afterwards, into a small spot

INDEX TO THE MAP OF MARS

Names	Approximate Centre		Remarks
	Lat	Long	
	°	°	
Airy Sea	45 N	80	
Arago Strait	25 S	350	Form indefinite on planet
*Banks Cape	10 S	312	De La Rue, Lockyer, Banks
Beer Continent	20 N	320	
Bessel Lake	18 S	98	As the inlet is doubtful
Browning Land	3 N	75	
Burchardt Land	25 S	230	
Burton Bay	5 N	5	Changed, as Beer has Continent
Campani Sea	65 N	80	
Cassini Land	47 S	245	Indefinite outline on planet
*Christie Bay	5 S	60	Kaiser, Lockyer, Christie
Copernicus Land	12 S	80	
Dawes Forked Bay	0	352	Named as desired by Dawes
Dawes Ocean	10 S	290	Includes several seas (Proctor)
De Tottingnez Sea	65 S	80	
De Lambre Sea	55 N	270	The Beer Sea of Proctor
De La Rue Ocean	20 S	40	
*Dreyer Island	25 S	265	Trouvelot, Dreyer, Green
*Flammarion Sea	15 S	270	All observers
Fontana Land	35 N	210	Very definite in 1873 (Knobel)
*Gill Land	65 S	180	Maunder, Trouvelot, Green
*Gruithuisen Bay	9 S	253	All observers
*Hall Island	23 S	48	Dawes, Maunder, Schiaparelli
Herschel I Continent	15 N	240	
Herschel II Strait	10 S	340	Very dark and definite
Hind Peninsula	8 S	265	
*Hirst Island	20 S	295	Trouvelot, Hirst, Green
Hooke Sea	30 S	245	
Huggins Bay	8 S	225	The inlet being doubtful
Jacob Land	50 S	40	Outlines on planet indefinite

* Where new names have been introduced the observers are given under remarks

Names	Approximate Centre		Remarks
	Lat	Long	
	°	°	
*Joynson Sea	73 S	180	Joynson, Maunder, Trouvelot
Kaiser Sea	5 N	288	
Kepler Land	28 S	80	Occasionally very light
*Knobel Sea	10 N	10	Burton, Knobel, Green
Kunowski Land	50 S	350	Marking on planet indefinite
Lagrange Peninsula	40 S	120	Lagrange Land of Proctor
Lambert Sea	50 S	333	Continues to S Polar Snow
Laplace Land	15 N	305	Formerly Madler Land
Lassell Sea	35 N	335	Very distinct in 1873
Leverrier Land	35 N	315	Seen crossed by dark lines (Knobel)
Lockyer Land	50 S	300	
Madler Continent	10 N	10	
Main Sea	0	270	Very faint shade on planet
Maraldi Sea	28 S	175	Outlines bold and definite
*Maunder Sea	55 S	180	Maunder, Niesten, Trouvelot
*Mitchel Mountains	73 S	275	Mitchel, Green, Brett
Nasmyth Inlet	40 N	310	
Newton Sea	55 S	10	Marking on planet indefinite
*Niesten Isthmus	36 S	210	Niesten, Trouvelot, Terby
*Noble Cape	25 S	185	Noble, Pratt, Green
Oudeman Sea	40 N	180	In place of Oudeman Inlet, doubtful
Phillips Island	15 S	315	Form on planet indefinite
*Pratt Bay	28 S	110	Pratt, Maunder, Green
Proctor Cape	3 S	313	Named by Dr Terby
Rosse Land	50 N	40	Rosse Strait being doubtful
Schiaparelli Lake	16 S	67	Schiaparelli, Dreyer, Green
Schmidt Bay	7 S	328	Named by Dr Terby
Schroter Sea	55 N	210	
Secchi Continent	10 N	135	
Terby Sea	22 S	81	Changed, as Lockyer has Continent
*Trouvelot Bay	20 S	168	Trouvelot, Niesten, Terby
Tycho Sea	38 N	50	
*Webb Land	42 S	180	Terby's Webb Isthmus being doubtful
Zollner Sea	40 S	270	Continues to S Polar Snow

* Where new names have been introduced the observers are given under remarks

MARS 1877

W

Fig 1

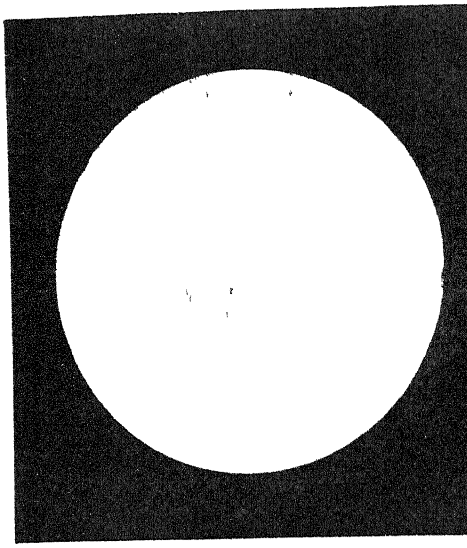

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Fig 2

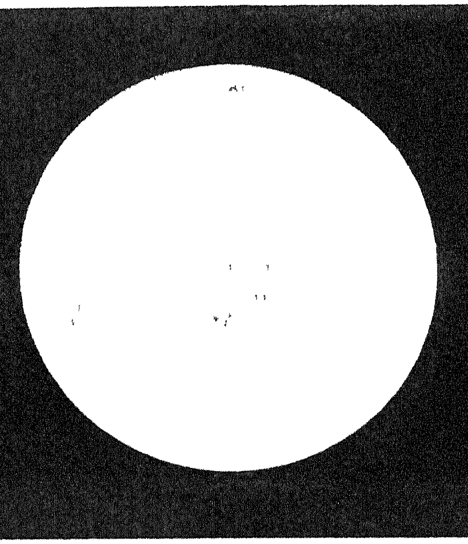

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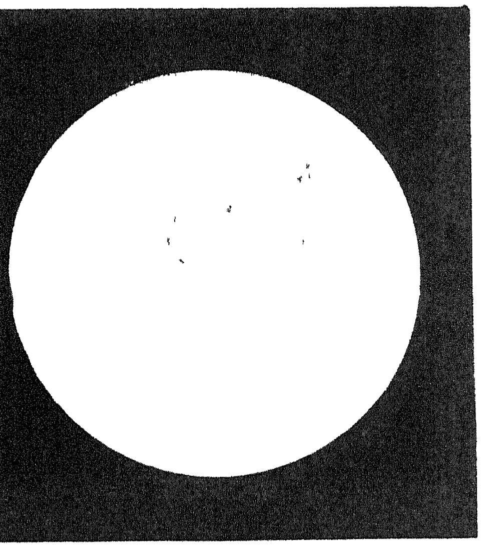
Fig 3



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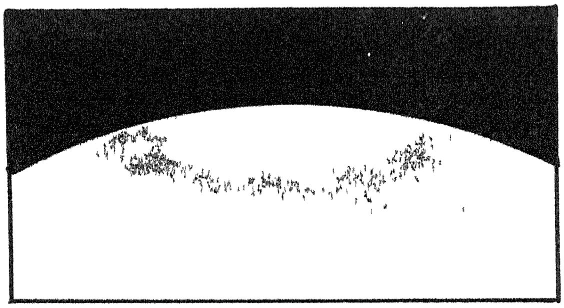
SOUTH POLE



Sep 1 10^h 30^m

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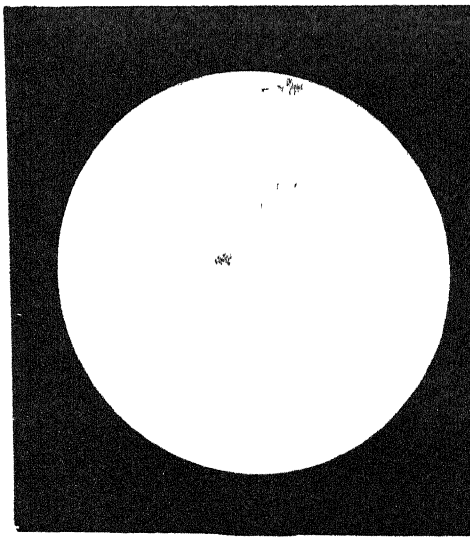
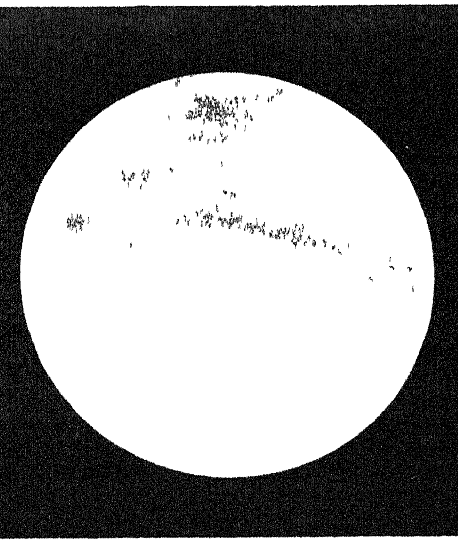
Fig 4



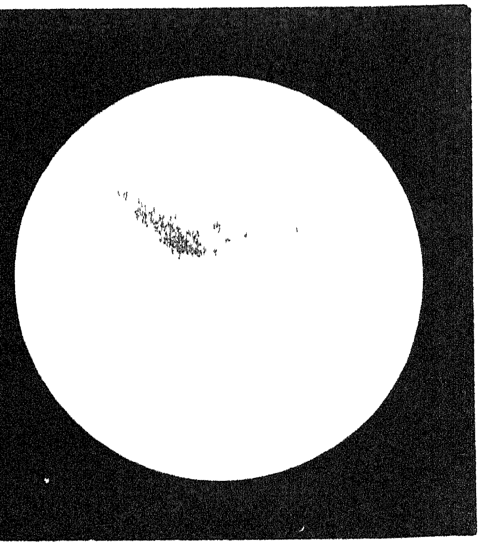
Sep 29_9^h Long 94°

Fig 5



Aug 21 12^h 30^m Long 131°

Fig 6



Sep 20_9^h 5^m Long 175

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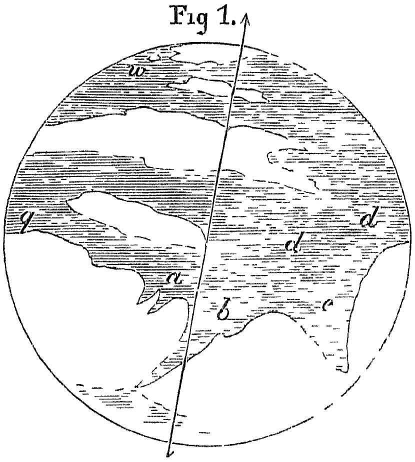
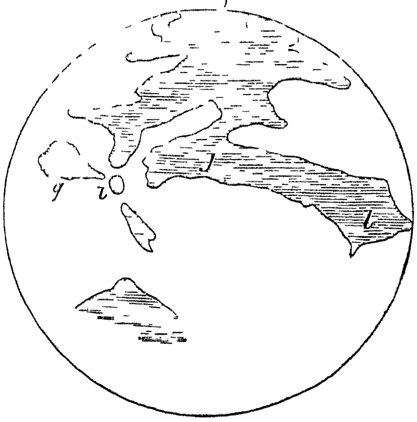
Fig 1.



a	Dawes Forked Bay	*g*	Terby Sea
b	Burton Bay	*i*	Bessel Lake
c	Christie Bay	*j*	Maraldi Sea
d	De la Rue Ocean	*l*	Trouvelot Bay
q	Part of Kaiser Sea	*w*	Mitchel Mountain

Fig 5



The above names are those to which reference is made in the Memoir For fuller particulars see the Map of *Mars*

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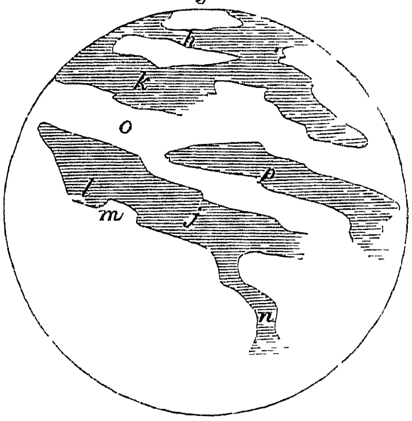
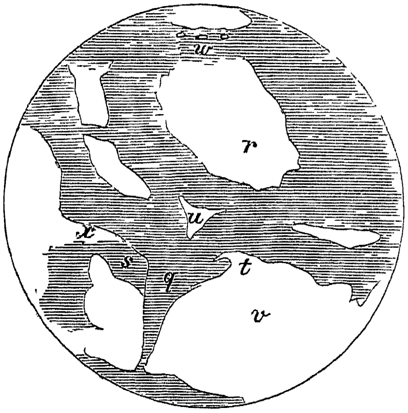
Fig 8



h	Joynson Sea	*q*	Kaiser Sea
j	Maraldi Sea	*r*	Lockyer Land
k	Maunder Sea	*s*	Main Sea
l	Trouvelot Bay	*t*	Banks Cape
m	Noble Cape	*u*	Hirst Island
n	Huggins Inlet	*v*	Beer Continent
o	Webbs Land	*w*	Mitchel Mountains
p	Hooke Sea	*x*	Hind Peninsula

Fig 11



The above names are those to which reference is made in the Memoir For fuller particulars see the Map of *Mars*.

MARS 1877

Fig. 7

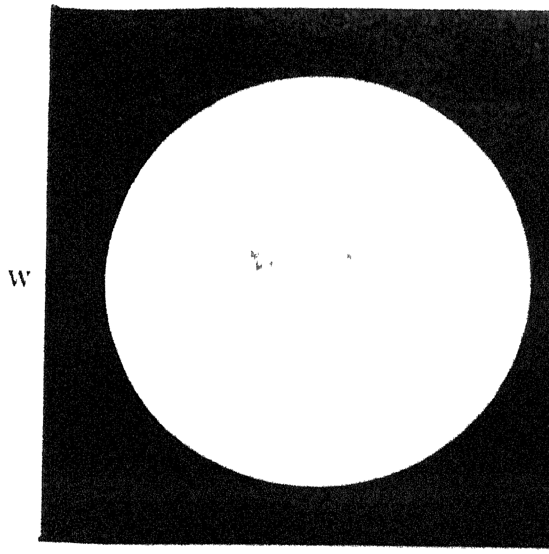


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Fig. 8

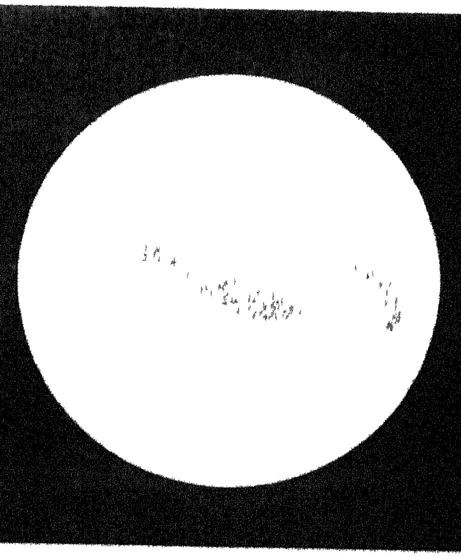

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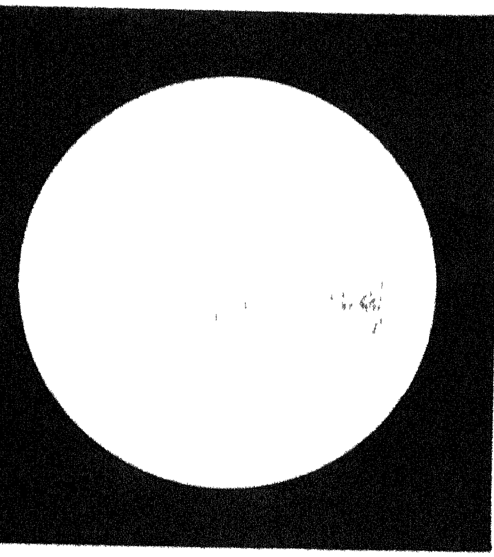
Fig. 9



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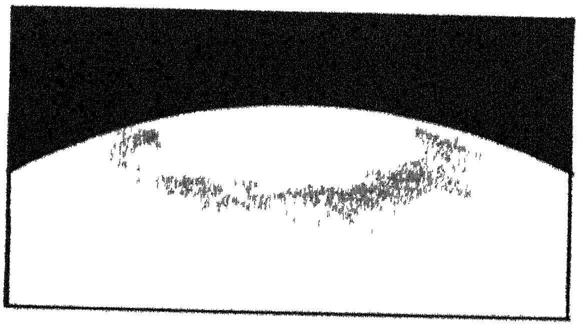
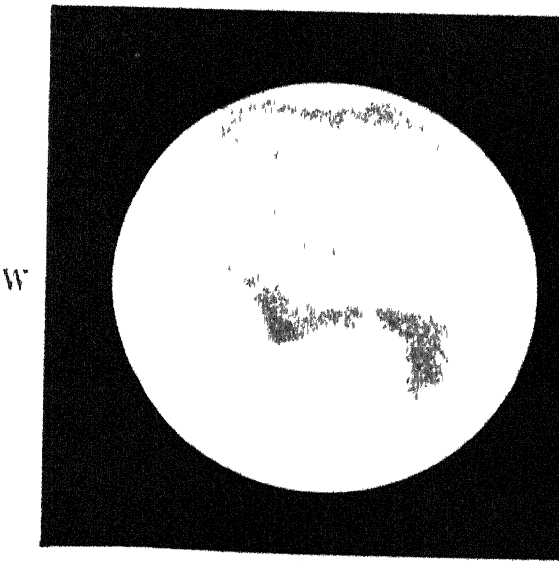
SOUTH POLE



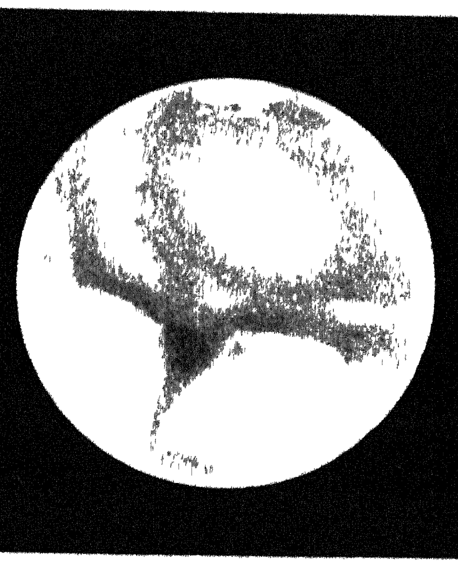
Sep [illegible]

Fig. 10



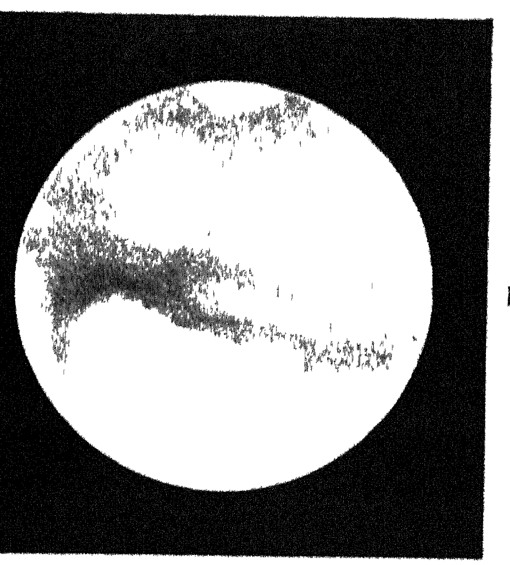
Sep 10 9h 15m Long 267

Fig. 11



Sep 10 11h 20m Long 297

Fig. 12



Sep 8 12h 30m Long 332

[illegible]

[illegible] 200 , 400

[illegible]

IV. *Double Star Observations made in 1877–8 at Chicago with the 18½-inch Refractor of the Dearborn Observatory, comprising I A Catalogue of 251 New Double Stars with Measures, II Micrometrical Measures of 500 Double Stars* By SHERBURNE WESLEY BURNHAM, M A

INTRODUCTION

THE astronomical observations contained in the following pages were made between July 22, 1877, and October 15, 1878, with the 18½-inch refractor of the Dearborn Observatory, and comprise a catalogue of 251 new double stars, and measures of 500 double stars already known, making a total of more than 1,400 micrometrical measurements

As but little use has been made of the great Equatoreal since its erection in Chicago, and no publications have been issued by the Observatory, a brief description of the instrument and its accessories may be of interest

HISTORICAL

The Chicago Astronomical Society was organised in 1862 At that time an object-glass of 18½ inches was still in the possession of Messrs Alvan Clark & Sons, which they had made for the University of Mississippi, and which was left upon their hands in consequence of the breaking out of the civil war of the rebellion. Steps were at once taken to secure what was then the largest object-glass in the world. Negotiations for its purchase were pending with other parties, but, by the prompt and decisive action of the Hon Thomas Hoyne, the glass was secured and a contract made for a complete mounting, at a cost of about $18,000 This amount was raised by subscription, the persons subscribing thereby becoming members of the Astronomical Society A massive tower, about 90 feet in height and attached to the building of the Chicago University, was erected, and the instrument, in the early part of 1864, put in position The tower alone cost $30,000, the entire expense of which was defrayed by the generosity of a single citizen, the Hon J Young Scammon Mr Hoyne, in his report as Secretary, giving a "history of the foundation of Dearborn Observatory," justly says of Mr Scammon, "his name is associated, by his culture and love of art and science, with the rise and progress of nearly every school, scientific enterprise, benevolent institution, and work of material progress in Chicago since it had a beginning" Mr Scammon has been President of the Astronomical Society from its organisation, and has liberally contributed towards the support of the Observatory A meridian circle of 6 inches aperture, by Repsold, was subsequently purchased, with which, under the directorship of Professor T H Safford, a zone of star observations was commenced for the great Catalogue of the German Astronomical Society This work was suspended by the great fire of October 1871, and has not been resumed.

THE EQUATOREAL

The Equatoreal has a clear aperture of 18½ inches and a focal length of 23 feet The finder has an object-glass of 3¾ inches in diameter The mounting is of the usual German form, and supported by a single block of stone resting on the top of the pier It has a Bond spring-governor driving clock, which latterly has carried the instrument very steadily At times I have found it necessary to increase the driving weight, and occasionally to overbalance the instrument, thereby reducing the resistance.

The right ascension and declination circles are respectively 20 and 30 inches in diameter, finely divided, and furnished with reading microscopes On the outer portion of each circle coarse divisions in black on white ground have been painted, reading by similar verniers to minutes in right ascension and to 5′ of arc in declination To the eye end of the telescope is attached a small terrestrial glass of about 1½ inch aperture, with a ball and socket joint so that it can be directed to the coarse divisions of the declination circle Two of the lenses of the erecting eye-piece were removed in order to shorten the focus and bring it, when directed to a point about 15 feet distant, within the limit of the draws of the glass With the "bull's eye" lamp ordinarily used the instrument can be set in declination or a reading taken without leaving the eye end of the telescope This reading glass can be instantly removed and attached to the opposite side of the main tube so as to be always convenient to the eye when the instrument is reversed I have never found it necessary in a single instance to use the fine graduations of either the right ascension or the declination circle. The smallest stars have been identified without difficulty, and for all practical uses these divisions, put on with a brush, serve as well as the most expensive and finely graduated circles

The right ascension circle can be read from the floor with the lamp, but in most positions it is troublesome to set in right ascension, for the vernier cannot be seen when the observer is within reach of the telescope. To obviate this difficulty and save time in an operation which has to be repeated many times each night, I have attached a device which, so far as I know, is new, and is so simple and efficient that a brief description of its construction may be of service to others

At the eye end of the telescope, from an axis placed exactly at right angles to the plane described by the tube when moved in declination—in other words, parallel to the declination axis—is freely suspended a thin disk, in shape nearly a semicircle and about 10 inches in the longest direction This carries an arm of about 7 inches radius, moving about a fixed pin near the middle of one side of the disk To this arm is attached a tolerably sensitive level filled with red fluid and having a long bubble Part of a circle is described on the disk, having for its centre the centre of motion of the level arm, and this is divided into hours and minutes of right ascension, as hereafter described, for three hours each side of the zero point, which is on a level with the centre of the circle when the telescope is in the meridian. The edge of the disk extends a little beyond, and is parallel with the divided part of the circle, and a friction wheel is attached to the extremity of the level arm with a projecting milled head. This wheel, having an elastic surface of rubber, presses against the circular margin of the disk By turning the head, the level arm is moved to and remains in any position of the scale In setting on an object, the telescope is first set in declination and the arm moved on the proper side of the zero point a distance equal to the difference between the right ascension of the object and the sidereal time The telescope is then moved in right ascension until the bubble comes to the middle of the level. In identifying a star it is only necessary to turn the arm until it is level, and add to or subtract from the sidereal time, as the case may be, the reading of the scale My practice has been to set my watch at the beginning of an evening's work to sidereal time The difference in rate for a few hours is of no practical consequence, and it is much more convenient than a chronometer It is quite necessary that the axis from which the disk is vertically suspended should be exactly in position, and adjusting screws are necessary For convenience I have placed this axis between the lower end of the finder and the main tube The level has to be adjusted on the arm so that its axis is parallel with the line joining the centre of motion of the arm and the point at which the reading is made When the axis of the disk is in its proper place and the level arm moved so as to bring the bubble into the middle, it will remain there with any motion of the telescope in declination, and give the same reading with the instrument reversed for equal distances from the meridian The disk, with its attachments, can be instantly removed, or can be reversed with reference to its axis, so that, when the telescope is on the other side of the pier, the graduated side of the disk shall be presented to the observer The value of the divisions of the scale, expressed in degrees for each 10 minutes of right ascension, were calculated by the formula

$$\sin a = \frac{R \sin b}{\cos l},$$

where a is the meridian distance, b the altitude, and l the latitude of the place These 10-minute spaces were then subdivided into five equal parts, making the 2-minute divisions in the first hour from the meridian equal to 0 045 of an inch They are of course a little less as they recede from the zero point of the scale, but still are wide enough to give with certainty the nearest minute It is but the work of a moment to set on a star, or take position of an unknown object, without leaving the seat.

I have found this simple contrivance of the greatest service in actual work It was roughly made of wood by myself as an experiment, but it has so completely answered the purpose that I have used it ever since. By some little modification it can be made to indicate the declination of the telescope as well as the right ascension

THE MICROMETER

The micrometer, made by Clark & Sons, is provided with five eye-pieces, the powers of which I have measured as follows:—

I	190
II	292
III	390
IV	638
V	925

In addition to the micrometer screw, there is, on the opposite side, a coarser screw, moving both wires for bisections or bringing the wires up to the star, and a rackwork by which the eye-piece can be moved by the wires at right angles to the axis of the telescope, and the object and the wires placed in the extreme edge of the field There is no provision for changing the coincidence of the wires The position circle is 8 inches in diameter, with two verniers From transits of circumpolar stars I have adopted 11″ 420 as the value of one revolution of the screw. In the early part of the work a slightly lower value was assumed from information; hence some few measures of wide pairs, as printed in communications relating to special objects in various Periodicals, will be found to differ slightly from the measures as recorded here. In distances where the change is sensible, the proper correction has been applied

CLASSES OF DOUBLE STARS OBSERVED

At the outset I determined to confine my observations as closely as possible, first, to pairs which, by reason of their extreme closeness or inequality, were peculiarly within the province of a large aperture; secondly, to double stars which, from the above conditions or the neglect of observers, have been measured but rarely or not at all in the last thirty or forty years, and thirdly, to certain difficult pairs recently discovered, principally by Mr Alvan G Clark and myself.

The second class of stars alluded to is a large and varied one, comprising many examples from the oldest lists of double stars, in fact, all Catalogues since Sir William Herschel, as well as occasional modern discoveries. Many observers have gone on from year to year observing over and over again the same familiar stars, of which *Castor*, γ *Virginis*, ε *Lyræ* may be cited as examples. Not that those stars are not important, but that they have been observed at the expense of hundreds of others equally important, and in one sense more important, for the reason that so little is known of their true character. It is the more to be regretted because most of these well-known systems are extremely easy—so easy, indeed, with the apertures generally employed, that the work of measuring them would for that reason be to some extent uninteresting to many observers, and fine refractors of 6 or 7 inches aperture and upwards ought, it would seem, to do more than deal only with couples which a 3-inch aperture will show perfectly. Many series of measures have been published from time to time, made with first-class instruments, which do not contain half a dozen stars each beyond the reach of an aperture giving one-third of the light. The result of all this is, that we have a large number of measures of a comparatively small list of stars, sometimes several hundred individual observations each, and only a very limited number, often none at all, of recent measures of a very much larger list. Of the four or five thousand double stars now known—leaving out the wide, faint, and apparently insignificant objects incidentally picked up in the sweeps of Sir John Herschel—the real character and rate of the relative motion, if any exists, of but a few dozen are understood.

In this connection I cannot forbear allusion to one distinguished observer who has followed no beaten track, whose indefatigable zeal is manifested in every field, whose skill as an observer, if it has been equalled at any time, has never been excelled The notes to the following measures will furnish some evidence of the wide range and the importance of the observations of Baron DEMBOWSKI While he has systematically observed, each year for a long time, most of the more important of the old binary systems, he has found time to measure a large number of the most difficult pairs from the Catalogues of STRUVE I, STRUVE II, HERSCHEL, and recent observers The address of Lord LINDSAY, President of the Royal Astronomical Society, in awarding the gold medal to Baron DEMBOWSKI in the early part of the present year, contains a brief account of his labours, but it is probably not generally known that his micrometrical measures of a large number of important pairs are as yet unpublished In the interest of my General Catalogue of Double Stars, I have been favoured with perhaps several thousand measures altogether, not included in his printed observations For several years he has given no inconsiderable portion of his time to measuring the new pairs discovered by myself with the 6-inch refractor. Of these double stars—upwards of 400 in number—not less than 1,500 measures have been made, only a few of which have been published. It is to be hoped that at an early day Baron DEMBOWSKI will publish his observations in a complete form They are scattered through many volumes of the *Astronomische Nachrichten*, and are apt to be overlooked without a systematic search for particular stars Omit the observations of DEMBOWSKI and O STRUVE, and our knowledge of nine-tenths of the double stars would not be materially advanced in the last thirty years.

Some of the new pairs in the accompanying Catalogue have been measured by Baron DEMBOWSKI, and I am fortunate in being able to present his measures in addition to my own Few observers would be able to measure such stars and those habitually observed by him with an aperture of only 7 inches It is another illustration of the truth that much more depends upon the observer than the size of the instrument I may add that nothing has been more gratifying and flattering to me than to find my measures of a difficult pair with 18½ inches aperture agreeing closely with the measures of Baron DEMBOWSKI with 7 inches.

METHODS OF OBSERVATION

In making my measures I have used almost exclusively a bright wire illumination, and always red light While I do not know that the latter is indispensable, I have found it so satisfactory that I have not tried any other colour With the proper amount of light from the right direction I find the wires smaller and sharper than with a bright field, and the illumination does not injuriously affect the visibility of the faintest stars. I have found it true that many, if not most, of the minute stars measured are more obvious under a suitable illumination of this kind than with the lamp removed altogether I have never seen a star so faint that it could not be equally well seen with a sufficient illumination to show the wires with desired distinctness

The micrometer is furnished with two hollow arms on opposite sides of the main tube, making an angle of about 45° with the optical axis of the telescope, from which the lamp is suspended These arms are attached to a collar which revolves about the fixed tube of the micrometer, the light passing through a series of holes in the latter and striking the wires directly The colour of the light is produced by a slip of red glass moving in a slot in front of the lamp in such a manner as to regulate the quantity of light as well as the intensity of the colour In making a measure of either distance or angle, these arms are turned so as to bring them approximately into the plane of the micrometer screw. The light then strikes the wires at right angles and produces the strongest illumination A constant position of the lamp with reference to the wires is doubtless important, and certainly tends to make the observations uniform The lamp can be readily shifted so as to give a bright field, but I have been unable to find in my own observations any special advantage in this method, even with bright stars

Most of the close pairs, and generally those under 1″, have been measured with the highest power Eye-piece I has been very rarely used, and II only in measuring wide pairs on poor nights Most of the measures have been made with III, IV, and V I have not indicated the power used in each measure, as it could be of little interest to other observers With regard to the use of powers, much depends upon the quality and aperture of the telescope and the atmospheric conditions at the particular time, and something upon the eye and habits of the observer.

In regard to the manner of observing, it should be stated that the Observatory is provided with no seat or couch for zenith observations or measuring stars in high altitudes, and it has been impossible for me to give that attention, in making measures, to the position of the head and body of the observer that the most experienced observers consider important. For moderate altitudes I have used a step-ladder, making each step a tolerably comfortable seat by the simple expedient of placing a box on the step below equal in height to the distance between the successive steps. This has answered reasonably well for zenith distances not less than 25° or 30°. I shall provide myself with better facilities for the next series of measures.

The method of double distances has always been employed, except in perhaps half a dozen instances of remote stars, which are noted in the measures. I have usually taken five readings for position and three on each side for distance. Shortly after commencing work I found there was some "shake" in the micrometer screw, and in the few measures made prior to that time (1877.681) I have rejected those of distance or given them to a single decimal place. The micrometer was then put in good order, and has so remained.

As to the performance of the telescope, the discoveries and measures themselves are the best evidence. I will only add that the object-glass, now that it is in much more perfect adjustment than it has been for many years, is fully up to the standard of excellence found in all the refractors manufactured by Messrs Alvan Clark & Sons. The separating power is nearly, if not quite, what it should be in accordance with the formula of Dawes—

$$\frac{4''.54}{\text{Aperture}}$$

With the highest power and under favourable conditions, I think it will fairly separate two equal stars with a distance of 0″.25.

STAR MAGNITUDES

In the magnitudes assigned to the smaller stars of the new pairs there is some room for doubt When they do not fall below 12 of the scale employed (STRUVE'S) I have not felt much hesitation, because standards of comparison are familiar The tendency would probably be, in using a large aperture, to overestimate the brightness, but when stars that are faint in such an instrument, and more or less difficult from their proximity to bright objects, are to be estimated, the absence of the practical extension of any scale to such limits renders the values somewhat uncertain, however consistent they may be with each other. Professor PICKERING, of the Harvard College Observatory, has commenced a series of photometric observations of double stars with comparisons running down to the limit of visibility with the 15-inch refractor. This systematic work cannot fail to be of the highest importance Even a few of these small stars, with the magnitudes absolutely determined by the methods employed by Professor PICKERING, will be of great assistance, by enabling the observer to have in his own mind some standards with which to compare.

MEASURES OF OLD DOUBLE STARS

In preparing a working list I have been guided by the principles and considerations already mentioned But, in order to fill up all the time, it was necessary that a considerable portion of this list should consist of wide pairs, such as could be observed when the weather was unsuitable for more interesting and difficult objects In selecting these I have taken such as seem the most important from the absence of any recent observations I have usually observed on each night the most difficult and close pairs I could measure under the circumstances The very best nights have been given to pairs under 0″ 4, or, if very unequal, under 1″ The magnitudes given in the eighth column of the measures are taken from the original Catalogue in which the pair is first found, with the exception of the *OΣ* pairs, the magnitudes of which are from DEMBOWSKI'S measures of the Pulkowa Catalogue.

NEW DOUBLE STARS

Much less time has been given to the discovery of new objects than might be supposed necessary from the number of new systems in the following pages When the time required to make more than 1,400 micrometrical measures is taken into account, it will be seen that no very large proportion, relatively, could remain for new fields Many of the new doubles are naked-eye stars, and some of them of the most interesting class

The following is a list of 51 naked-eye stars whose distances are within the limits adopted by Struve, with the corresponding Catalogue number —

β	Star	Distance	β	Star	Distance
491	δ Andromedæ	27 86	616	γ Bootis	26 18
492	B A C 201	1 82	618	ι^1 Libræ	1 86
506	η Piscium	1 02	625	ω Herculis	1 90
513	48 Cassiopeiæ	1 07	627	52 Herculis	1 83
518	Ceti 389	1 57	633	γ Draconis	20 88
521	Persei 67	5 86	637	W^1 XVIII 28	7 26
522	μ Arietis	19 10	648	B A C 6480	0 61
524	20 Persei	0 34	653	μ Aquilæ	21
531	L 6275	2 43	654	52 Sagittarii	2 93
535	38 Persei	0 96	660	B A C 6963	9 44
544	36 Tauri	25 06	668	B A C 7080	4 64
547	47 Tauri	0 89	669	ω^2 Cygni	17 26
550	α Tauri	30 45	672	71 Aquilæ	30 52
553	o^2 Orionis	28 58	675	51 Cygni	2 78
555	β Orionis	0 2	685	2 Pegasi	29 82
570	11 Monocerotis	25 79	690	μ Cephei	19 27
578	L 14545	1 72	694	Lacertæ 4	0 50
587	15 Hydræ	0 45	697	19 Cephei	19 75
588	Hydræ 96	2 37	702	δ Cephei	19 37
590	29 Hydræ	10 80	703	α Lacertæ	30 16
596	Leonis 222	2 38	717	8 Andromedæ	7 61
599	65 Leonis	1 78	718	64 Pegasi	0 46
600	Crateris 36	1 25	720	72 Pegasi	0 40
605	B A C 4149	1 25	730	27 Piscium	1 42
608	15 Canes Ven	1 22	733	85 Pegasi	0 67
612	B A C 4559	0 23			

In conformity with my experience heretofore, a number of previously known double stars from the various Catalogues have been found to have other and closer components In most instances the difficulty of the object will account for its non-discovery by prior observers The following is a list of 35 such pairs, with the distances of the old and new companions and the corresponding number in my Catalogue :—

β	Double Star	New	Old	β	Double Star	New	Old
487	Σ 17	2 04	27″06	600	♅ N 26 = Sh 120	1 25	61″53
510	♅ V 92	1 59	53 56	601	♅ IV 112 = S 627	0 81	28 16
511	Σ 171	3 69	29 69	608	Σ 24 App I (15 Canes Venatici)	1 22	288 30
524	Σ 318 (20 Persei)	0 34	14 04				
530	Σ 366 *rej*	1 99	48 97	614	OΣ 271	0 60	
536	S 437	0 44	36 72	617	S 663 = ♅ VI 117	2 73	59 44
550	Σ 2 App II (Aldeb)	30 45	113 9	618	♅ VI 44 (ι Libræ)	1 86	57 46
551	H 3261 (96 Tauri)	6 26	30 75	620	H 4803	0 86	50 25
555	Σ 668 (β Orionis)	0 2	9 14	632	OΣ 336	5 46	42 80
557	Σ 721	0 46	24 32	638	Σ 2287	1 71	22 33
558	Σ 14 App I (δ Orionis)	33 79	52 80	639	Sh 264	0 5	17 30
559	H —	1 74	50 85	643	Σ 2342	8 86	28 80
575	Σ 1057	0 69	15 87	652	Σ 2539 = ♅ II 99	4 78	5 60
579	OΣ 173	0 84	16 60	655	Σ 2549	1 93	22 86
580	Pollux			686	OΣ (App) 220	0 4	41 67
582	Σ 1179	3 76	19 75	702	Σ 58 App I (δ Cephei)	19 37	40 48
584	S 571	1 61	44 97	713	Σ 2959	8 31	13 77
587	♅ V 120 (15 Hydræ)	0 45	45 75	733	— (85 Pegasi)	0 67	14 40

The date of the discovery of the new stars is generally that of the first measure The reference number in the first column is continued from the preceding series of Catalogues of new double stars, which have been published as follows —

First Catalogue	Nos 1 to 81	*Monthly Notices R A S*	March 1873
Second ,,	,, 82 ,, 106	,, ,,	May 1873
Third ,,	,, 107 ,, 182	,, ,,	December 1873
Fourth ,,	,, 183 , 229	,, ,,	June 1874
Fifth ,,	,, 230 ,, 300	,, ,,	November 1874

Sixth Catalogue	Nos 301 to 390	*Astronomische Nachrichten,*	No 2062
Seventh ,,	,, 391 ,, 436	,, ,,	No 2103
Eighth ,,	,, 437 ,, 452	*American Journal of Science*	July 1877
Ninth ,,	,, 453 ,, 482	*Monthly Notices R A S*	December 1877

The present work forms the tenth Catalogue of the series, and extends the number of new pairs to 733

Of the 251 stars in this list, 75 pairs are from 0″ to 1″ in distance, and 59 pairs from 1″ to 2″

The weather during the period covered by these observations has been very unfavourable much of the time For weeks together there has not been a single good night Two evenings each week the instrument has been at the service of visitors.

I have made a few observations in other directions, but they are of minor interest, and, with the exception of the two new nebulæ, are not included in the results here given I have intended to give my whole time to the more important and extensive field of double-star work, and particularly to that portion of it most worthy of so large a refractor, now best known as the instrument with which the companion of *Sirius* was discovered by Mr Clark in 1862

In conclusion, I may add that my work has been wholly a labour of love During the business hours of every day I have been otherwise fully occupied, and hence my observations have been prosecuted often at the expense of rest, sleep, and recreation. I submit the results to the Royal Astronomical Society as the first contribution of the great Equatoreal of the Dearborn Observatory

Chicago, October 15, 1878

ABBREVIATIONS USED IN THE NOTES

Arg	*denotes*	Argelander
A C	,,	Alvan Clark
A G C	,,	Alvan G Clark
β	,,	Burnham
Da	,,	Dawes.
De	,,	Dembowski
Du	,,	Duner
En	,,	Engelmann
Flm	,,	Flammarion
Gl	,,	Gledhill
♅	,,	Herschel I
H	,,	Herschel II
Hd	,,	Harvard College Observatory
Hl	,,	Hall
Hn	,,	Holden
J	,,	Jacob
Kn	*denotes*	Knott
Ma	,,	Madler
Mh	,,	Mitchel
Mu	,,	*Annalen Konig Stern Munchen,* xvii
Ne	,,	Newcomb
Σ	,,	Struve
OΣ	,,	Otto Struve
O S	,,	Ormond Stone (including measures of H A Howe and Winslow Upton)
Se	,,	Secchi
Sh	,,	South and Herschel
Shp	,,	Schiaparelli
Sm	,,	Smyth
Wn	,,	Winnecke
W S	,,	Wilson and Seabroke

I.—*Catalogue of 251 New Double Stars*

No.	Star Catalogue	R.A. 1880	Decl. 1880	Position Angle	Distance	Mags.		Epoch 1870+	Notes
		h m s	° ′	°	″				
483	L 47348	0 2 49	40 11	44.7	2.37	7.5	11.8	8.657	One of a wide pair
484	Arg (51°) 9	0 3 30	51 22	154.1	1.92	8.0	12.0	8.647	
				158.4	1.99	7.5	11.8	8.673	
485	Arg (57°) 22	0 4 30	58 6	145.7	0.3±	8.5	8.5	7.553	
				151.3	0.41	9.0	9.2	8.796	
486	Ceti 33	0 8 19	−8 27	3.4	3.35	6.0	11.5	7.775	
				6.7	2.80	6.0	12.0	8.701	
487	Σ 17	0 10 18	28 38	29.1		8.0	9.[illegible]	7.731	A and B
				28.7	27.06	8.0	9.5	8.775	
				264.7	1.93		12–13	7.731	B and C
				266.1	2.16		12.5	8.775	
488	L 465	0 17 52	−4 8	347.7	3.30	8	11	7.703	
				346.7	3.25	7	10.5	8.594	
				348.5	3.31	7.5	10.0	8.610	
				348.8	3.43			8.701	
489	Arg (43°) 80	0 19 40	43 31	178.8	2.5±	8.5	11	7.785	Very poor
				187.7	3.43	8.0	12.5	8.671	
490	13 Ceti	0 29 3	−4 15	65.3	37.12	6	12–13	7.780	Difficult
491	δ Andromedæ	0 32 54	30 12	298.9	27.98	3	12.5	7.725	
				300.7	27.86			8.742	
				298.4	27.74			8.744	
492	B.A.C. 201	0 38 28	54 34	153.5	1.82	6	12	8.671	
				151.7	2.01	6	12	8.796	
493	Arg (50°) 137	0 39 4	50 27	51.1	0.8±	9.0	9.0	7.586	
				51.7	0.83	9.2	9.2	8.671	
				52.6	0.88			8.673	
494	L 1266	0 40 52	−1 54	166.3	1.42	8	8	7.703	
				170.6	1.35	8.2	8.2	8.701	
495	L 1308	0 42 25	18 2	230.9	0.58	7.5	7.5	8.701	
496	L 1416	0 45 17	12 8	1.9	5.18	6	12–13	8.701	8 mag. in L. and 7 mag. in Arg.
				2.9	5.06	7	13	8.775	
497	B.A.C. 239	0 45 55	60 28	171.6	121.20	6.0	9.0	8.663	A and B
				150.9	0.9	9.0	11–12	7.586	B and C
498	L 1459	0 46 33	9 9	155.3	2.50	8	12–13	7.742	
				157.2	2.56	8	12	8.775	
499	γ Cassiopeiæ	0 48 50	60 1	348.7	52.22	3	13	8.647	Two brighter in 175°.7 and 198°.1
				348.5	52.33		13	8.796	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	° ′	°	″				
500	L 1539	0 48 51	30 1	291 7	1 17	8 0	8 0	7 969	
				286 2	0 92	8 3	8 3	8 747	Unsteady
501	L 1958	1 0 40	− 5 17	30 5	2 25	8 0	11 0	8 206	
				29 3	2 85	8 0	12 5	8 775	
502	W¹ O 1077	1 2 13	15 9	306 6	3 58	8	11–12	7 818	
				306 7	3 40	8 2	11 5	8 775	
503	L 2307	1 10 54	9 58	136 9	5 39	7–8	12–13	7 742	
				136 4	5 53	8	12	8 627	
				136 9	5 40	8	11 5	8 775	
504	L 2318	1 11 9	1 13	274 2	1 27	8 0	11 5	7 942	
				280 4	1 54	7 5	12 0	8 775	
505	θ Ceti	1 18 2	− 8 48	60 5	58 8	3		7 703	Excessively faint
506	η Piscium	1 25 4	14 44	15 3	0 91	4	11	8 675	Small star blue
				10 3	1 11	4–5	11	8 733	
				13 0	1 03		11	8 775	
507	Arg (26°) 264	1 29 16	26 10	155 5	2 28	7 5	10 0	7 736	8 6 in Arg
508	Arg (26°) 276	1 32 26	26 20	71 1	1 02	9 0	9 5	7 725	
509	L 3170	1 37 25	8 58	98 7	0 90	8 5	9 0	7 742	
				88 6	0 64	8 5	8 7	8 733	
				93 1	0 60	8 2	8 5	8 775	
510	H V 92	1 42 4	15 43	337 4	1 59	8	12	8 063	A and B
				326 4	53 56		8	8 063	A and C
511	Σ 171	1 42 40	− 2 1	160 2	29 92	8 5	8 5	7 859	A and B
				160 1	29 47			7 953	
				159 2	29 67	8 4	8 5	8 775	
				316 7	3 53		12–13	7 859	B and C
				318 0	4 15			7 953	
				313 3	3 38		12 5	8 775	
512	Arg (18°) 244	1 47 12	18 42	31 8	1 8	9	12–13	7 678	
				25 5	1 42			7 695	
				24 5	1 48	9	13	8 675	
513	48 Cassiopeiæ	1 52 7	70 19	264 9	1 25	5	7	8 649	A and B Very unsteady
				262 8	0 90	5	7 5	8 660	
				265 5	0 98	5	8	8 796	
				49 4	23 98		13–14	8 796	A and C
514	L 3698	1 53 57	−13 54	285 5	6 20	8	12	7 695	
515	L 3707	1 54 38	15 59	241 7	1 58	7 5	12–13	8 030	
				244 9	1 44	8	12	8 733	
516	L 3851	1 59 6	− 1 33	104 0	1 17	8 0	8 3	7 862	
				286 0	0 98	8 0	8 2	7 994	
517	Ceti 374	2 18 54	− 4 26	248 4	10 82	7 5	12–13	7 994	L 4476

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
		h m s	° ′	°	″			
518	Ceti 389	2 23 11	9 2	138 8	1 27	6–7 10 5	7 882	B A C 764
				139 2	1 87	7 0 11 0	7 994	
				137 3	1 57	6–7 11 5	8 030	
519	W^1 ii 367	2 23 38	− 2 48	237 7	0 97	8 5 10 5	7 942	
520	L 4858	2 30 49	− 4 6	207 7	0 6 ±	9 0 10 5	7 942	Poor measure
				214 7	0 78	9 0 10 5	7 994	
521	Persei 67	2 34 59	47 45	153 2	5 80	6 5 11 0	8 649	L 4942
				154 3	5 92	6 0 11 5	8 671	
522	*μ* Arietis	2 35 36	19 30	265 8	19 10	6 12–13	8 747	
523	Arg (33°) 517	2 41 54	33 28	210 3	2 25	9 0 11 0	7 850	In field with Σ 310
524	20 Persei	2 46 9	37 51	185 9	0 25 ±		8 096	A and B Suspected elongation
				157 7	0 39		8 655	Certainly double distance too large
				158 6	0 36	6 7	8 657	Well seen Distance too large
				159 7	0 26	6 7	8 675	
525	B A C 920	2 52 0	21 8	236 1	14 04		8 151	AB and C = Σ 318
				105 1	0 59	7 0 7 0	7 717	
526	*β* Persei	3 0 21	40 30	154 8	59 37	B = 13	7 736	A and B
				155 8	58 21		8 649	
				144 2	67 83	C = 13+	7 736	A and C
				145 2	67 62		8 649	
				192 7	81 99	D = 10	7 736	A and D
				192 4	81 86		8 649	
				114 6	10 51	E = 12 5	7 736	D and E
				115 6	10 77		8 649	
527	W^1 ii 1057	3 0 35	−13 43	60 4	0 85	8 0 8 5	7 829	Closely sp Σ 356
528	W^1 ii 1086	3 2 26	− 4 3	193 8	1 01	8 5 8 5	7 942	In field with Σ 358
				201 2	1 02	8 5 8 5	7 994	
529	L 6006	3 8 9	− 9 1	220 4	2 17	8 0 12 0	7 698	
				219 5	2 62		8 091	
530	Σ 366 *w*	3 8 17	22 30	42 1	48 93	7	7 728	A and B
				41 3	49 02		8 063	
				195 2	2 11	10 0 11 0	7 728	B and C
				197 5	1 86		8 063	
531	L 6275	3 17 26	− 8 13	62 2	2 84	7 12–13	7 829	In Heis, 6–7 m
				58 1	2 02	6 5 12 0	7 994	
532	L 6585	3 27 25	−10 27	263 4	3 58	7½ 12 +	7 698	A and B
				269 3	2 57		8 091	
				310 1	80 4	8	7 698	A and C
533	B A C 1101	3 28 9	31 17	149 3	0 43	7 0 7 0	8 675	6½ m in B A C
534	L 6741	3 33 1	− 8 54	195 0	2 58	7½ 10 5	7 810	
				197 5	2 05	7 10 5	7 947	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	° ′	°	″				
535	o, 38 Persei	3 36 47	31 54	54 8	1 00			7 678	
				58 6	0 44			8 030	
				55 9	0 96			8 657	
				57 9	0 93	4	8 5	8 657	
536	W- iii 945	3 39 8	23 49	339 3	0 47	8 5	9 0	8 657	A and B
				333 1	0 46	8 0	10 0	8 675	
				336 8	0 39	8 5	9 0	8 733	
				302 3	36 85		8 0	8 675	AB and C
				302 6	36 59		8 0	8 733	
				11 2	18 17		12	8 675	C and D
537	Arg (24°) 563	3 39 53	24 28	189 1	0 64	8½	12	7 717	
				182 7	0 57	8 5	9	8 096	
538	Yar 1634	3 40 21	23 44	138 0	2 27	10	11	7 728	
539	W^1 iii 809	3 43 11	- 1 52	270 4	2 79	9 0	11 0	7 818	Near β 401
				273 9	2 79			7 953	
540	Arg (31°) 669	3 48 21	31 48	323 8	1 34	8	11	8 655	A and B
				328 2	1 10	8 2	12 0	8 657	
				57 1	57 51		8	8 655	A and C
				57 3	56 77		8 5	8 742	
541	W^1 iii 923	3 49 53	− 1 37	259 8	1 34	8 5	10 5	7 953	
542	Anonymous	3 50 23	− 7 18	198 4	1 65	9	10	7 859	
543	W^1 iii 974	3 51 24	− 1 30	32 0	11 15	8 5	10 5	7 818	
544	36 Tauri	3 57 11	23 47	257 9	25 06	6	12–13	7 856	
545	L 7556	3 59 24	37 42	312 3	0 92	8 0	11 0	7 736	
				307 7	1 10			7 882	
				307 6	1 16	8 0	11 5	8 665	
				312 6	0 92	8 0	12 0	8 671	
546	W iii 1323	4 2 49	41 28	24 3	0 92	8	8	8 671	
547	47 Tauri	4 7 25	8 58	352 6				7 678	
				363 4				7 818	Clouded before distance.
				362 1	0 89	5	8	8 030	
				223 1	32 20		12–13	7 994	AB and C
548	L 8027	4 10 53	−10 23	347 0	6 24	7	11–12	7 862	
549	W^1 iv 458	4 23 2	−12 13	189 3	7 71	8	12–13	7 942	
				188 7	8 00			8 003	
550	α Tauri (Aldebaran)	4 29 2	16 16	111 6	30 26			7 829	B = 13-14 m
				103 3	30 72			7 856	
				112 1	30 38			7 994	
				35 2	114 66			7 870	Ḫ's companion
				35 2	114 34			7 950	
551	96 Tauri	4 42 52	15 42	57 2	30 75			8 091	A and B
				205 7	6 26			8 091	B and C

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	° ′	°	″				
552	Orionis 11	4 45 3	13 27	360 ±	0 8 ±	7	10	7 966	
553	o^2 Orionis	4 49 38	13 19	47 3	28 35	5	12	7 856	
				48 1	28 81			7 873	
554	ε Aurigæ	4 53 21	43 39	275 9	42 88	4	12	8 046	A and B
				275 0			12	8 796	
				317 9	51 79		13	8 796	A and C Very unsteady
555	β Orionis	5 8 47	− 8 20	160 3				8 091	B and C Not much doubt
				179 1	0 31			8 153	Certainly double
				178 9	0 40			8 170	
				1 7	44 53	12–13		7 810	A and D
				1 3	44 42			7 829	
556	L 10159	5 18 39	− 2 36	238 2	0 79	6½	11 8	8 170	
557	Σ 721	5 23 16	3 3	149 8	24 32	7 0	9 0	8 153	A and B C
				143 1	0 43	9 5	9 5	8 153	B and C
				141 8	0 50			8 170	
558	δ Orionis	5 25 52	− 0 23	226 2	32 46	B = 13–14		7 829	
				228 6	34 71			7 856	
				226 1	34 20			7 994	
				359 5	52 80	2 0	6 8	7 994	Σ's companion
559		5 40 36	0 2	82 1	1 78	9 0	11 5	8 096	A and B
				88 5	1 70			8 156	
				202 5	50 70	9 0	9 0	8 096	A and C
				201 6	51 00			8 156	
560	L 10958	5 41 37	29 41	208 2	0 94	8 0	8 0	7 882	Poor measure
561	L 10969	5 41 58	12 23	4 0	19 70	7	13	8 093	
562	L 11127	5 47 41	36 55	110 ±	0 3 ±	8	8	8 047	
563	L 11156	5 47 46	15 29	183 9	7 42	7 8	11 0	8 063	
564	Lam 843	5 54 59	− 1 34	90 ±	1 ±	9 0	11 0	7 953	Difficult
565	L 11741	6 3 41	−14 3	100 4	1 02	8	12	8 211	7½ m in L and W
566	Monocerotis 21	6 8 41	− 4 32	219 7	1 43	8 5	12–13	8 030	L 11916
567	Monocerotis 23	6 9 34	− 4 53	249 0	4 12	7 5	11 5	8 030	L 11949
				251 1	3 46			8 156	
568	Canis Majoris 33	6 18 36	−19 43	155 1	1 35	7 0	7 3	8 211	
569	L 12315	6 19 36	−10 52	120 7	1 84	8 2	10 5	7 994	
570	11 Monocerotis	6 23 0	− 6 57	57 3	25 52	5	12–13	7 856	A and D
				55 3	25 88			8 030	
				55 8	25 98			8 170	
571	W· vi 956	6 33 2	13 5	316 2	2 73	6 0	12 0	7 947	In Hers, 6–7 m
572	O^1 Arg 6032	6 55 44	−20 30	143 8	5 03	7 0	10 5	7 876	
573	L 13642	6 56 11	−10 42		1 ±	8	8	7 856	
574	L 13821	7 1 18	−11 8	306 7	1 76	8	12	8 041	Near Σ 1026

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	°	°	″				
575	Σ 1057	7 9 21	−15 16	198 2	0 85	8	8	8 153	A and B
				200 3	0 53			8 214	
				2 6	15 95		9 8	8 036	AB and C
				1 7	15 80			8 153	
576	L 14117	7 11 5	35 23	143 1	1 48	7	13	8 046	
577	L 14272	7 14 21	0 38	136 8	0 90	7 5	7 7	8 211	A and B; AB = Σ 1074
				9 9	14 54		13	8 211	AB and C
578	L 14545	7 21 46	−17 37	53 6	1 72	6 5	11 8	8 197	In Heis, 6 m
579	OΣ 173 [illegible]	7 26 40	33 23	219 1	0 84	8 0	11 5	8 236	A and B
				232 2	16 60		12 0	8 236	A and C
580	Pollux	7 38 1	28 19	274 9	43 0	2	13–14	7 953	A and B
				70 8	172 1			8 063	A and C
				70 8	174 52			8 230	
				123 4	1 ±	10	12–13	8 063	C and c
				132 6	1 40			8 153	
				90 5				8 230	A and D
				75 8				8 230	A and E
581	L 15743	7 57 44	12 38	176 9	0 40	8	8	8 088	A and B
				176 9	0 39			8 227	
				183 3	4 55		10 5	8 088	AB and C
				189 4	5 01			8 091	
				183 3	4 71			8 227	
582	Σ 1179	7 58 6	12 25	204 8	19 76	8½	8½	8 088	A and B
				204 3	19 75			8 091	
				60 7	3 87		12	8 088	B and C
				58 9	3 66			8 091	
583	L 15959	8 3 18	− 6 21	68 5	1 82	8 5	8 7	8 099	
584	P VIII 124	8 32 58	19 58	292 2	1 76	8 0	12 0	8 030	A and B
				289 9	1 46			8 068	
585	Cancri 109	8 34 20	20 54	101 8	0 3 ±	8	9	8 068	Poor measure
				110 9	0 40	7 5	9 0	8 153	
586	Monocerotis 237	8 41 49	−16 37	53 2	0 75	6 5	9 0	8 153	L 17355
587	15 Hydræ	8 45 41	− 6 44	158 1	0 48	6	9	8 156	A and B
				161 8	0 43			8 227	
				357 4				8 099	A and C
				356 2	45 75			8 186	
				54 2				8 099	A and D
				52 2	49 99			8 186	
588	Hydræ 196	9 10 30	1 14	122 6	2 33	6½	11 0	8 170	In Heis, 6–7 m
				123 9	2 42	6½	11 0	8 211	L 18302
589	L 18585	9 20 15	7 3	219 1	2 30	7½	12–13	8 088	

Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
	h m s	° ′	°	″				
) Hydræ	9 21 22	− 8 42	175 5	10 68	7 0	11 5	8 131	
			178 2	10 93	6½	12 0	8 211	
¹ ix 477	9 23 33	− 2 36	35 5	0 78	7 7	8 5	8 063	Near τ Leonis
			36 1	0 68			8 153	
Arg 10209	9 49 16	−15 38	192 5	9 56	6½	12–13	8 225	7 m in O Arg
			191 2	10 04			8 227	
Hydræ	10 4 4	−11 46	118 4	50 76			8 236	Faint companion
onis 150	10 16 20	15 58	143 4	1 58	6 0	10 5	8 244	
ionymous	10 42 ±	−14 23 ±	14 6	2 32	9 0	11 0	8 208	
onis 222	10 43 2	17 47	280 6	2 59	6½	13	8 244	L 20827
			274 1	2 18			8 285	
g (24°) 2285	10 49 17	24 14	46 4	0 91	8 5	11 0	8 208	
			47 4	0 85			8 246	
Leonis	10 54 32	6 45	220 9	46 76	5½		8 236	Faint
Leonis	11 1 50	2 30	85 1	1 68	5½	11 5	8 046	
			84 0	1 93		11 5	8 208	
			78 3	1 93			8 244	
			82 1	1 59			8 285	
N 26	11 10 54	− 6 29	226 4	1 25	6½	12 0	8 153	A and B
			97 3	61 72		8	8 153	A and C
			97 3	61 34			8 208	
IV 112	11 22 54	−16 40	331 6	28 01	7 5		8 323	A and B
			331 4	•			8 353	
			331 5	28 32			8 359	
			226 9	0 81	8 0	9 0	8 323	B and C
'2262	11 40 39	15 40	73 4	0 57	8 5	11 0	8 153	7½ m in L
C 3992	11 42 28	14 57	336 2	1 59	7 0	11 0	8 208	
			339 2	1 46	6½	11 0	8 211	
eonis	11 42 56	15 15	345 0	77 14		13	8 236	Very faint
			343 3	76 00		13–14	8 320	Single distance
C 4149	12 13 58	−21 30	143 4	1 31	6	8	8 153	
			145 0	1 20			8 320	
n 35	12 19 48	−14 17	95 3	1 32	7	9	8 285	Unsteady
			100 5	1 43			8 323	Good L 23250
4572	12 35 2	− 0 48	312 3	1 07	8 5	11 0	8 151	
			317 1	1 42			8 244	
			318 2	1 15			8 255	
			315 5	1 02			8 277	
'anes Ven	13 4 11	39 10	283 1	1 27	5½	10 5	8 249	A and B
			286 8	1 17			8 381	
im 27	13 4 28	− 4 18	356 1	0 89	7	11	8 323	Very unequal
inis 504	13 17 28	−20 19	18 3	4 02	6 8	10 5	8 244	L 24812 (6½ m)

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	° ′	°	″				
611	L 25159	13 31 15	−14 7	258 7	4 88	8 5	12 0	8 353	Found in looking for H 2666
				260 1	4 38			8 359	
612	B A C 4559	13 33 40	11 21	57 2	0 3 ±	6	6	8 244	Diffused
				56 8	0 26	6	6	8 323	First class measure
				54 4	0 19			8 438	Very good
613	Arg (35°) 2494	13 46 3	35 16	146 2	0 78	9 0	9 0	8 422	
614	OΣ 271 rej	13 48 1	10 44	270 2	0 59	8	12 0	8 323	
				266 5	0 60	8	11 5	8 438	
615	O-Arg 14509	14 17 52	49 4	237 1	2 35	8 5	9 5	8 296	
616	γ Bootis	14 27 15	38 50	98 8	26 20			8 249	About 12–13 m
				98 4	26 17			8 252	
617	S 663	14 42 23	−23 45	219 5	59 72	6½	8	8 323	A and B
				219 6	59 16		9	8 362	
				337 4	2 88		11 5	8 323	B and C
				335 9	2 59			8 362	
618	ι^1 Libræ	15 5 23	−19 20	110 7	57 41			8 320	A and B
				110 3	57 68			8 323	
				110 5	57 29			8 359	
				25 7		10	10	8 320	B and C
				24 3	1 99			8 323	
				22 6	1 98			8 362	
				24 6	1 62			8 383	
619	Serpentis 55	15 37 34	14 3	356 6	0 42	6½	7	8 246	L 28666
				362 8	0 73			8 452	Very unsteady
620	H 4803	15 38 54	−27 41	166 8	0 86	7 5	7 5	8 383	A and B
				214 1	50 25		9 0	8 383	AB and C
621	W^2 xv 1130	15 45 51	45 7	75 1	0 5 ±	7 5	8 0	8 476	Very poor
622	π Scorpii	15 51 36	−25 46	133 2	49 82	6	12	8 383	
				132 1	50 16			8 419	
623	L 29127	15 54 51	− 6 38	238 4	0 97	8 0	9 0	8 452	
624	O^1 Arg 15565	16 15 41	−22 50	323 0	1 21	8 0	9 5	8 438	Near 5 Ophiuchi
				320 4	1 03	8 0	10 0	8 507	
625	ω Herculis	16 19 52	14 19	173 5	2 16	5	12	8 540	
				175 9				8 610	Too poor for distance
				176 6	1 71		11 8	8 627	
				103 3	33 60		11 5	8 540	A and C
				103 0	34 00			8 627	
626	φ Ophiuchi	16 24 16	−16 21	35 8	32 83	4	12–13	8 323	
				36 0	32 10			8 507	
627	52 Herculis	16 45 43	46 12	309 3	2 02	5	10	8 299	
				309 5	1 67			8 337	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
		h m	° ′	°	″			
				308.0	2.02	11	8.395	
				310.3	1.64		8.408	
				309.8	1.79		8.476	
628	W- xvii 359	17 13 55	32 47	5.6	0.54	9.0 9.5	8.411	
629	Arg (32°) 2883	17 14 7	32 11	349.8	0.96	8.2 9.0	8.395	
				341.9	1.03	8.5 9.0	8.414	
630	Arg (32°) 2891	17 15 53	32 25	225.2	1.60	8.5 11.0	8.395	
				225.7	1.72	9.0 10.5	8.414	
631	Ophiuchi 255	17 33 47	− 0 35	69.7	0.35	7.0 7.0	8.512	Well separated
				70.7	0.38	7.0 7.0	8.622	Separated
632	OΣ 336 *rej*	17 43 32	34 19	344.9	5.7	12–13	7.504	AB
				342.3	5.46		8.441	
				165.0		6.3 10.3	7.504	AC = OΣ 336
				164.8	42.80		8.441	
633	γ Draconis	17 53 49	51 30	152.3	20.69	B = 13 m	8.381	A and B
				152.0	21.07		8.395	
				227.1	47.89	12–13	8.381	A and C
				13.7	56.68	12–13	8.381	A and D
634	67 Ophiuchi	17 54 38	2 56	179.8	45.94	B = 12	8.573	A and B
				143.0	54.70	5.6 9	8.573	A and C
				120.2	8.46	C = 13 m	8.753	C and D
635	Arg (1°) 3565	17 56 40	1 35	112.9	1.70	9 10	7.509	A and B
				116.2	1.47		8.636	
				122.6	68	8.5	7.509	A and C
636	L 33280	18 2 4	2 12	127.8	4.92	7 12	8.622	
				126.2	4.92	7 12.5	8.636	
637	W xvii 28	18 3 53	3 7	195.2	7.26	6.5 12.5	8.636	6 m in Herc and Arg
638	Σ 2287 *rej*	18 4 19	2 34	152.5		9.0 9.0	7.509	A and B
				151.5	22.33		8.622	
				7.0		C = 11.8	7.509	B and C
				14.8	1.63		8.622	
				9.7	1.79		8.626	
639	Sh 264	18 11 40	−18 40	147.0	0.76	7 8	8.622	A and B
				163.6	0.38	7.5 7.5	8.701	
				51.8	17.25	8.0	8.622	AB and C
				51.6	17.34		8.701	
640	Herculis 443	18 16 3	27 28	349.5	2.42	7–8 12.0	8.449	L 33880
641	L 33897	18 16 43	21 27	350.9	1.01	7.5 9.0	8.449	
642	Anonymous	18 26 50	−10 29	91.5	4.11	9.0 11.0	8.504	
643	Σ 2342	18 29 41	4 50	337.1	8.69	B = 12–13	7.531	A and B
				340.1	8.85		8.515	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870 +	Notes
		h m s	° ′	°	″			
				337 5	9 04		8 636	
				7 3	28 90	5 7 8 5	7 531	A and C Mags of Σ
				8 2	28 70		8 515	
644	L 34468	18 30 34	4 51	318 8	17 36	7 12	7 531	Near the preceding
				321 2	17 37		8 698	
645	Hercules 475	18 38 1	19 21	304 0	9 9	7 12	7 534	Distance uncertain
646	113 Herculis	18 49 41	22 30	34 2	35 48	6	8 681	A and B
				24 9	40 68		8 681	A and C
				159 2	7 0	12-13 = 12-13	7 531	B and C
647	Arg (13°) 3816	18 50 29	13 27	14 1	1	9 9	7 520	A and B
				217 0	20	9	7 520	A and C
648	B A C 6480	18 52 30	32 45	309 7	0 59	6 0 9 0	8 460	
				315 4	0 62	6 0 10 0	8 473	
649	Arg (32°) 3285	18 54 24	32 19	12 5	1 63	8 5 11 5	8 460	
				13 2	1 51	8 5 11 8	8 473	
650	L 36918	19 25 6	6 8	142 0	7 4	8	7 520	A and B
				332 6	10 ±		7 520	A and C Faint stars
				252 8	25 ±		7 520	A and D
651	Arg (27°) 3409	19 25 44	28 2	289 0	6 4	8 5 12 5	7 529	
				291 5	6 36		8 473	
652	Σ 2539	19 27 16	28 1	334 0		B = 13	7 529	A and B
				328 8	4 78		8 473	
				3 0	5 8	7 9 9 7	7 529	A and C = Σ 2539
				4 5	5 60		8 473	
				247 1			7 529	B and C
653	μ Aquilæ	19 28 13	7 8	285 5	21 21		8 622	A and B
				285 9	21 16		8 627	
				277 6			7 509	A and C
				272 3	21 42		1 627	
				194 4	5 2 ±	13 = 13	7 509	B and C
654	52, (h^2) Sagittarii	19 29 24	−25 10	162 5	2 87	5 11 0	8 515	
				162 3	3 21	10 5	8 698	
				157 5	2 72	11 0	8 701	
655	Σ 2549	19 29 49	63 4	276 7	49 79	7 7 7 7	8 476	A and B
				289 4	22 86		8 476	A and C
				85 9	27 63	C = 8 9	8 476	B and C
				152 6	1 93	D = 12-13	8 476	B and D
656	L 37475	19 35 47	51 32	262 7	0 4		7 570	
				254 0	0 56	8 0 9 0	8 408	
				258 0	0 55	8 0 9 3	8 534	
657	W² xix 1209	19 38 51	22 21	146 3	1 ±	9 10	7 520	
				142 5	0 90	9 5 11 5	8 777	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	° ′	°	″				
658	B A C 6762	19 39 1	26 50	295 2	0 57	6 5	10	8 529	Near OΣ 382
659	Ru 7844 ...	19 48 48	6 50	318 7	12 3			7 509	
				316 0	12 32	6½	12 5	8 625	
660	B A C 6963	20 9 40	43 1	318 1	9 44	7	13–14	8 647	Heis 6–7 m
661	Cygni 166	20 12 39	40 0	67 5	12 85	6 5	12–13	8 395	B A C 6986
				66 5	12 36	6	12 5	8 647	Large star reddish
662	Anonymous	20 14 1	−19 59	300 ±	1 7 ±	9	10	8 520	
663	L 39260	20 17 21	53 13	79 4	8 3	6	12–13	7 573	Distance uncertain
664	Aquilæ 264	20 18 36	5 7	285 1	9 66	7	12–13	8 622	L 39236 Very unequal
665	γ Cygni .	20 17 55	39 52	195 8				7 499	A and BC
				197 2				7 666	
				196 7	140 3			7 709	
				196 2	140 43			8 395	
				196 5	140 58			8 655	
				306 2		10	11	7 499	B and C
				304 4	1 39			8 408	
				304 8	1 42			8 647	
666	Arg (53°) 2392	20 19 9	53 15	121 4	1 7	8½	11	7 581	
667	L 39280	20 19 38	7 29	233 2	9 14	7½	11	8 468	
668	B A C 7080	20 25 49	−10 16					8 701	Not seen Good night
				28 5	4 31	6 0	12 0	8 594	
				32 8	4 95			8 622	
				25 6	4 66	6 5	11 5	8 678	
669	ω² Cygni	20 26 20	48 33	342 5	17 26	5¼	13 5	8 649	A and B
				86 3	56 28		10 0	8 649	A and C
670	Arg (13°) 4435	20 27 16	13 32	55 5	0 74	8 5	8 8	7 744	
				61 1	0 77			7 766	
671	O² Arg 20741	20 29 34	62 3	334 8	0 5 ±	8 0	10 0	7 573	
672	71 Aquilæ	20 32 8	− 1 31	280 6	30 14		12 5	8 622	
				281 1	30 90		12 5	8 698	
673	Arg (20°) 4680	20 36 28	20 18	298 2		7 7		7 573	
				298 0	4 10	7 0	11 8	8 777	
674	Yar 9020	20 37 53	−21 19	120 ±	1 3 ±	8	10 5	7 509	
675	51 Cygni	20 38 31	49 54	102 3	3			7 589	A and B
				98 8	2 78	6	12–13	8 476	
				103 3	2 77		13	8 647	
				182 4	25 39		12	8 395	A and C
				328 4	32 85		12	8 395	A and D
676	ε Cygni	20 41 20	33 31	323 0		B = 12 0		7 504	
				319 7	37 59			8 305	
				320 0	37 86			8 436	Mean = 320° 9, 37″ 72 (1878 1)

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	° ′	°	″				
677	W¹ xx 1372	20 42 23	33 56	300 6		7 0	12 0	7 496	
				301 6	10			7 583	
				301 6	9 66			8 408	
678	L 40036	20 54 20	− 8 49	182 3	2 2	8½		7 526	
				189 5	2 45	8 0	11 5	8 777	
679	Anonymous	21 1 25	43 12	71 5	0 3 ±			7 556	
				64 7	0 38	10	10	8 647	
680	Arg (53°) 2546	21 1 53	53 10	131 4	0 5	8	8 4	7 570	Distance uncertain
681	Ru 9004	21 7 40	16 27	241 5	2 32	6 5	10 8	8 537	Not in Heis
				237 8	2 83	7 0	11 5	8 698	
				239 7	2 38	7 5	11 5	8 701	
682	L 41222	21 8 30	4 12	105 6	5 64	7 5	12 0	7 766	
683	L 41683	21 20 44	−20 44	198 4	2 04	8½	11	7 526	
684	W¹ xxi 517	21 23 53	− 5 57	133 9	1 11	9 0	9 2	8 622	In the field with β 72
685	2 Pegasi	21 24 31	23 7	334 4	29 91	5½	13	7 703	
				333 8	29 74	12–13		8 395	
686	OΣ (App) 220	21 33 44	55 14	117 5	0 4			7 586	A and B
				11 1		8 0	8 0	7 586	AB and C
				11 0	41 67			8 647	
687	R 5340	21 34 54	55 15	187 8	0 5 ±			7 586	Near the last
				189 1	0 89	8 0	9 0	8 647	Distance too large
688	R 5364	21 37 43	40 30	213 4	0 3			7 553	
				205 3	0 34			7 720	
				211 6	0 48	7 5	7 5	8 408	
				206 5	0 31	7 8	7 8	8 673	
689	Aquarii 88	21 38 43	2 26	235 2	1 76	7 0	10 5	7 725	L 42384
				245 4	1 68	8 0	11 5	8 678	
				243 1	1 95			8 701	
690	μ Cephei	21 39 50	58 14	260 1	19 06	5	12	8 425	A and B
				259 5	19 49	5	12	8 663	
				299 4	41 19			8 425	A and C
691	Arg (17°) 4529	21 40 4	17 12	328 3	1 16	9 0	11 5	7 760	Difficult
692	L 42601	21 44 49	31 17	11 2	2 46	7 5	11 0	7 703	A and B
				10 5	2 51	7 5	11 0	8 780	
				119 2			11	7 703	A and C
				119 4	36 89			8 780	
693	L 42730	21 49 54	− 7 33	50 7	0 97	8 0	10 5	7 772	
				54 6	0 92	7 5	10 0	8 633	
				57 0	0 91	8 0	10 5	8 701	
694	Lacertæ 4	21 57 6	43 54	351 3	0 54	6 0	8 5	8 660	B A C 7681
				353 2	0 47	6 0	8 5	8 673	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags.		Epoch 1870+	Notes
		h m s	° ′	°	″				
695	Arg (60°) 2330	21 58 33	60 31	147 7	2 70	8 0	12–13	8 425	Very unequal
				147 9	2 38	8 0	12 0	8 668	
696	Arg (15°) 4557	21 58 44	15 19	351 1	0 82	9 0	9 5	7 717	Distance too large
				356 5	0 48	8 0	8 5	8 701	
697	19 Cephei	22 1 27	61 42	95 8	19 75	6	12	8 663	
698	L 43308	22 5 55	6 18	337 4	9 76	7 0	12 0	8 706	
				337 9	10 18	7 5	12 0	8 775	
699	W¹ xxii 114	22 7 45	7 7	180 6	2 07	8	12	7 766	
				189 7	2 11	8 3	12 5	8 775	
				191 6	1 95	8 0	12 0	8 777	
700	Arg (48°) 3728	22 21 35	49 5	333 1	8 ±	8	12	7 583	
				334 6	9 83	8 5	12 0	8 793	Unsteady
701	L 43867	22 22 9	11 42	280 9	1 36	7 5	10 5	7 703	
				279 0	1 11	7 5	10 0	8 775	
702	δ Cephei	22 24 43	57 48	286 3	19 17		13	8 649	A and B
				285 2	19 57		13	8 663	
				191 9	40·88	3 0	5 3	8 649	A and C
703	α Lacertae	22 26 20	49 40	299 0	30 14	4	12	7 581	
				298 6	30 18		12	8 471	
704	Arg (66°) 1518	22 27 0	66 56	207 3	2 3 ±	9	11–12	7 548	
705	L 44111	22 28 17	40 12	158 0	1 5 ±	7 0	12 5	8 529	Very difficult
706	Arg (67°) 1450	22 28 21	67 41	18 1	2 3	8 0	11 8	7 548	A and B
				253 5	28 5		10 0	7 548	A and C
707	L 44138	22 28 46	38 43	46 6	1 86	8 0	12 5	8 476	
708	Arg (67°) 1451	22 29 32	67 41	288 6	8	9	11–12	7 548	Near No 706
709	Anonymous	22 35 19	− 3 10	8 5	1 99	8 5	10 5	7 807	
				11 1	2 18			7 947	
				7 0	1 94	8 5	9 0	8 775	
710	Arg (28°) 4439	22 36 56	29 5	231 2	0 59	8 5	8 6	8 657	
711	Lamont 3180	22 39 29	10 34	79 9	0 72	8 5	10 5	8 594	27^s *p* a 7 m star
712	Arg (58°) 2518	22 49 58	58 36	291 6	1 02	9 0	9 5	7 581	In a small cluster
713	Σ 2959	22 50 55	− 3 53	102 2	13 65	6 5	10 3	7 804	A and B
				102 2	13 90			7 947	
				95 9	8 31	C -	12–13	7 947	B and C
714	B A C 8084	23 7 57	− 3 17	145 5	0 57	7	10	8 636	
715	Aquarii 290	23 8 25	−11 20	255 9	3 07	7	12	7 695	L 45490
				251 0	3 70	7 5	11 0	7 760	
				257 5	3 53	7	11 5	8 610	
				259 1				8 627	Clouded
				256 3	3 10	6 5	12 0	8 775	
716	Anonymous	23 9 15	−9 43	208 4				7 526	
				208 9	1 70	9–10	10-11	7 695	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
		h m s	° ′	°	″				
717	8 Andromedæ	23 12 11	48 22	162 0	7 4			7 589	
				159 3	7 86	5	12–13	8 471	
				162 8	7 58		12 5	8 671	
718	64 Pegasi	23 16 3	31 9	87 4	0 47	5½	7½	8 675	
				83 4				8 701	Suddenly diffused
				89 9	0 45	6	9	8 733	
719	W^1 xxiii 363	23 19 23	15 2	10 9	1 11	8 0	11 0	7 862	
720	72 Pegasi	23 28 0	30 40	127 2	0 35	5 8	6 0	8 675	
				124 4				8 720	Clouded
				129 7	0 41	6	6	8 733	
				130 5	0 43	6	6	8 736	
				127 4				8 755	Clouded
				127 7				8 769	Poor seeing
				127 2	0 43	6	6	8 775	
721	W^1 xxiii 592	23 30 7	− 7 47	136 4	0 41	9	9	7 845	
				140 0	0 51			8 610	
722	Arg (41°) 4886	23 32 33	41 50	348 6	7 15	6 8	12 5	8 529	7 0 m in Arg
723	L 46375	23 34 32	− 0 15	168 4	3 60	7 5	11 0	7 780	
				170 6	4 32			7 876	
				167 1	3 76	7 0	11 0	8 622	
				167 8	3 45	7 0	11 8	8 722	
724	W^1 xxiii 691	23 34 46	7 18	85 7	0 75	9 0	9 5	8 733	
725	L 46464	23 36 37	−12 0	240 3	4 10	7 0	11 0	7 775	
				234 3	4 51			7 876	
726	Anonymous	23 40 1	− 13 25 4	324 2	0 91	8 5	10 5	7 856	
727	W^2 xxiii 866	23 41 25	24 55	313 9	8 67	7	12 13	8 622	
				313 0	8 80	7	12 13	8 769	
728	L 46752	23 46 5	42 50	173 0	1 24	8 5	8 5	7 785	
				172 3	1 04	8 2	8 2	8 668	
729	O^1 Arg 23124	23 49 15	−18 26	346 4	11 42	8	12	7 703	7 m in Arg
730	27 Piscium	23 52 32	− 4 13	264 9	1 44	5–6	10 0	7 942	
				265 9	1 52		11 0	8 610	
				266 5	1 29		11 5	8 627	
731	L 47033	23 53 27	− 8 28	256 3	1 66	9 0	10 5	7 856	
				259 4	1 48	8 5	9 0	8 701	
732	W^1 xxiii 1086	23 54 18	7 50	153 1	6 03	8 5	11 0	7 742	
				151 2	6 23	8 5	10 0	8 610	
				152 8	6 03	8 5	11 0	8 701	
733	85 Pegasi	23 55 52	26 27	272 4	0 77	6	12 5	8 675	A and B
				271 5	0 59		12 0	8 733	
				278 0	0 66		13	8 775	

No	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
		h m s	° ′	°	″			
				33 9	14 06	6 9	8 395	A and C
				33 8	14 38		8 471	
				33 1	14 52		8 625	
				33 9	14 64		8 675	

New Nebulæ.

		3 28 51	−10 16	62 1	206 7	.	7 997	
		13 3 21	−15 53	90 6	131 6	.	8 236	

Notes to the Catalogue of New Double Stars

No. 485

A very difficult pair near β *Cassiopeiæ* The duplicity of this star was suspected at the time of finding β 253 with the 9.4-inch of the Dartmouth College Observatory. Dε finds the distance of the latter less than 0″.4. This is closer, and probably under 0″.3. As stated in the note to 253, it is one of a small triangle of stars between that pair and β *Cassiopeiæ*.

No. 486. *Ceti* 33

This is a naked-eye star, 6 m. in Argelander and Heis. It is L. 158.

No. 487. (A and B = Σ 17.)

The new star is very minute. No other measures of the wide pair since 1830.

Σ	P = 29°.3	D = 26″.33	1830.0
β	28.9	27.06	1878.2

The two measures of BC give,

P = 265°.4 D = 2″.04 1878.2

No. 491. δ *Andromedæ*

The small attendant was seen with the Washington 26-inch in 1875, but no record made of it at the time, and subsequently I was not quite certain of the identity of the star. The three measures give —

P = 299°.3 D = 27″.86 1878.4

No 492 B.A C. 201

This very unequal pair was found on the occasion referred to in the note to the preceding pair. Not included in my former lists, and no other measures.

No 493

The preceding of a small triangle of 9 m stars, 2^{m} 59^{s} *p* *ν Cassiopeiæ*, and 8′.7 *n*.

No 497 B A C 239

A naked-eye star, with a difficult double companion. B is **Arg** (50°) 137.

No 506 *η Piscium*

A very fine, but excessively difficult pair. There is no known pair among stars of this magnitude, or brighter, with so close and minute a companion. I found the highest power necessary to show it satisfactorily, and all the measures were made with that eye-piece. The small star appeared decidedly blue. The following is the mean result of the three measures.—

P = 12°.9 D = 1″.02 1878.7

No 509

In a low-power field with Σ 155, $28^{s}.9$ *p* and 5′.6 *n*.

No 510 (A and C = ♅ V 92.)

The principal star is **Rumker** 430. The new star is very minute. On one or two nights later I could not see it well enough to measure. I find no other measures of the wide pair in the present century. Some change is probable.

	P	D	
♅	P = 322°.7	D = 51″.27	1783.0
β	326.4	53.56	1878.1

No. 511. (A and B = Σ 171.)

The new star is very faint. Relative motion in the wide pair is clearly shown. The following are all the measures to this time.—

	°	″	
Σ	P = 157·6	D = 27·89	1829·9
De	159·0	29·12	1865·1
β	159·8	29·69	1878·2

The three observations of BC give:—

°	″	
P = 316·0	D = 3·69	1878·2

No. 512.

This unequal and difficult pair is in the field with the well-known double, γ *Arietis*, and was connected with that star by South and Herschel.

	°	″	
Sh.	P = 85·2	D = 228·76	1823·9
β	84·6	223·3	1877·9 single distance

There is a very minute star about midway between this and γ *Arietis*. This double companion is similar to that of *Regulus*, but closer and rather more difficult. The first measure is uncertain in distance.

No. 513. 48 *Cassiopeiæ*.

An extremely easy pair for a naked-eye star. It is a little strange that it has not been detected before, as a very small aperture will show it. It has been measured once by De., whose measure, and a mean of my two observations, are as follows:—

	°	″		
β	P = 264·4	D = 1·04	1878·7	
De.	265·1	1·05	1878·7	Mags. 5·0 . . 7·0.

The third star, C, is excessively faint. A larger star, 82° : 45″.

No 518 *Ceti* 389

Heis gives this as a naked-eye star, 6–7 m In the B A.C it is 7 m. A mean of the three measures gives —

P = 138°4 D = 1″57 1878 0

No. 521 *Persei* 67.

Heis gives this as a naked-eye star, 6–7 m A fine, and not very difficult pair. The following is a mean of my measures :—

P = 153°7 D = 5″86 1878 6

No 524. 20 *Persei*. (A and C = Σ 318.)

The principal star of this well-known pair is a very close and difficult pair. My first angle differs widely from the three later measures, but as the elongation was not quite certain, there may not be any change in the interval. A mean of the three measures gives —

P = 158°7 D = 0″34 1878 7

This distance is certainly too large. I do not think it can exceed 0″·25, and it is probably less than that, as it was not separated fairly on any occasion

Struve's companion seems relatively fixed

♅	P = 239°5	D = 14″03	1783 5
Σ	236 8	14 08	1829 1
OΣ	238 2	13 99	1851 8
β	236 1	14 04	1878 1

No 525 B.A.C. 920

Discovered at Washington with the 26-inch in 1875 It was subsequently seen very well with the 6-inch. It is 16′ *s* of the well-known binary, ε *Arietis* Not very difficult as the stars are of the same magnitude.

No. 526. β *Persei.*

The celebrated variable star, *Algol* Sm noted the largest of the companions measured. The others have not been observed before.

No. 530. *Arietis* 161, Σ 366 *rej*

The duplicity of the companion was suspected by Σ, but finally rejected in *Mensuræ Micrometricæ*. It is described in the early Catalogue, "Class IV. et I. (7), (9), (9) De Classe I est dubium" It has never been measured before.

No. 535. *o*, 38 *Persei.*

A difficult and rather unequal pair Magnitude of B somewhat uncertain. It has been measured once by De This observation, and a mean of my measures stand as follows:—

	°	″	
De	P = 60.5	D = 0.96	1877.8
β	56.8	0.83	1878.2

Most observers will require a larger aperture to deal with this pair It is difficult with the large instrument, except under very favourable conditions.

No. 536. (*Pleiades*) AC = S 437.

A very close and difficult pair in the *Pleiades*, 1ᵐ 13ˢ.2 *p. Alcyone*, and 4′ 52″ *n*. A mean of the three measures of the close pair gives:—

°	″	
P = 336.4	D = 0.44	1878.7

The only measures of the wide pair (S 437) are:—

	°	″	
S	P = 299.7	D = 34.57	1824.0
β	302.4	36.72	1878.7

The fourth star, D, is faint, and not heretofore observed.

No. 537. (*Pleiades.*)

One of the outer stars of the *Pleiades*, and a very difficult pair from the great difference in the magnitudes. It has been observed twice by DE., and the two sets of measures are as follows:—

	°	″	
DE.	P = 194·4	D = 0·4±	1877·8
β	185·9	0·60	1877·9

The difficulty of the object will account for the difference in the measures of the angles. DE. calls the magnitudes 8·0 and 10·0. My distances are probably too large.

No. 538. (*Pleiades.*)

Another pair in the *Pleiades*, but very small stars. Place from the Washington Catalogue, where it is $30^{s}\cdot 4$ *f. Alcyone*, and 20″·5 *s.*

No. 542.

This star is not in any Star Catalogue I have. Place with the micrometer from W^1 in 1001.

No. 545. L. 7556.

A difficult pair in the field with OΣ 531, $8^{s}\cdot 1$ *p* and 3′ 54″ *s*. The mean of the four measures is:—

°	″	
P = 310·0	D = 1·02	1878·2

The components are very unequal.

No. 547. 47 *Tauri.*

An elegant pair, and in distance and magnitudes not unlike 38 *Persei.* It has been measured on three nights by DE., and the observations are too important not to be given in detail:

°	″	
P = 357·1	D = 0·89	1877·74
361·8	0·85	1877·83
360·3	0·73	1878·13

Most observers, and certainly those less experienced, will find it too difficult for an aperture of only 7½ inches. The mean of the two sets of measures is as follows:—

	°	″				
β	P = 359.7	D = 0.89	1877.8	Mags	5 .	8
De.	359.7	0.82	1877.9		5	7.5

The third star, C, is very faint.

No. 550 *Aldebaran* (A and C = ♅ VI 66 = S. 452 = Σ 2 App. II)

The new companion, much nearer than the well-known attendant of ♅ and Σ, is very minute, and not unlike in appearance and difficulty Hall's outer satellite of *Mars* The colour and magnitude of the large star make the comparison more striking I saw the companion very fairly with the aperture contracted to 12 inches. It has been measured on three nights by Hl with the 26-inch The following are the mean results:—

	°	″	
β	P = 109.0	D = 30.45	1877.9
Hl	110.5	31.26	1878.0

The change in the direction and distance of the old companion is due to the proper motion of the large star, as will be seen from the following:—

	°	″	
♅	P = 37.0	D = 87.75	1782.0
Σ	36.0	109.08	1836.0
De	34.9	112.66	1863.4
β	35.2	113.94	1877.9

No 551 96 *Tauri.* (A and B = H 3261)

H ’s companion has a minute attendant about the same distance from A. The description in H of A and B is —

°	″			
P = 55.8	D = 25±	Mags	6	13

The third star appears to have about one-half the light of B

No 554 ε *Aurigæ*

The distance in the second measure of B came out 49″ 93, in which, as shown by later measures, there is some error in reading The third star very faint. Subsequently a nearer star was detected, 224° 5 29″ 31 (1878 9)

No 555 β *Orionis* (A and B = ♅ II 33 = Sh 53 = Σ 668)

An elongation in the 9 m companion of Σ and ♅ was suspected as long ago as 1871 with the 6-inch refractor, and the attention of observers called to it in a communication in the *English Mechanic.* The star was examined subsequently a great many times with the same aperture, and although there was always a peculiar appearance about the vertical diameter, I could not fully satisfy myself that it was really double In 1876 I learned from Mr Herbert Sadler that he had suspected the companion to be double independently, and I again tried it under the most favourable circumstances with the 6-inch, and with about the same result as before, but the appearance of the star was always such as to encourage further attempts. The attention of other observers at various points, with larger apertures, was solicited, but the results so far as they reached me were either negative or unfavourable to the suspected double nature of the small star. As early as practicable in 1877 the 18½-inch was directed to the solution of the difficulty, and the star examined on a great many nights, only three of which were sufficiently perfect in definition for micrometrical measures The highest power only gave a small elongation, but that appeared to be well defined and certain, and I have no doubt now of the duplicity of this star I have spent more time in observing this star by way of getting at this result than any other star in the heavens, although some of the pairs in my Catalogues have required attention for a year or more before their true character could be positively ascertained. In regard to the measures of distance, it should be stated that they more properly represent the longer diameter of the star The true central distance is certainly less than 0″ 2 It is the closest, and perhaps most difficult, pair of this class I have ever seen I hope during the coming season to obtain a better series of measures (*Monthly Notices*, June 1878)

The faint and distant star, C, was detected by **Mitchel**, but has never before been measured. He called it 15 m. He gives a diagram of the three stars in the *Sidereal Messenger* for May 1846. It is apparently unchanged.

In the *Radcliffe Observations* (vol. xxii.) a 9–10 m. star is measured from *Rigel* as follows:—

P = 243°.3 D = 37″.12

This is certainly a mistake. There is no star of any magnitude in this place. The observation probably belongs to some other portion of the heavens.

No. 556. L. 10159.

A fine unequal pair near η *Orionis*, *sf.* There is something strange about the absence of this star from most of the Star Catalogues. It is not in **Bode**, B.A.C., **Schj.**, **Weisse**, **Yarnall**, **Rumker**, or **Lamont**. The only Catalogue I have been able to find it in is **Lalande**, where it is rated 8 m. It appeared to me much brighter, and was noted 6½ m. It may prove to be variable. On one or two nights subsequently the small star was seen, but was not measurable.

No. 557. (A and B = Σ 721 = ♅ IV. 45 = Sh. 57.)

The small star of this wide pair found to be a very close and exceedingly difficult pair. Excellent conditions are necessary to observe it with any aperture. There is no evidence of change in the distant stars:—

Σ	P = 150°.8	D = 24″.21	1830.2
En	151.2	23.99	1863.1
β	149.8	24.32	1878.1

No. 558. δ *Orionis* (A and C = Σ 14 App. I = ♅ V. 10.)

An excessively faint companion nearer than that previously known, perhaps the faintest of any of the minute attendants to large stars noted in this Catalogue. The mean result of the measures is as follows:—

P = 227°.0 D = 33″.79 1878.9

There is no change in the wide pair since the first observations —

	°	″	
Σ	P = 359·2	52·74	1835·7
β	359·5	52·80	1878·0

No 559.

The wide pair, AC, was noted by H and Sm It is in the nebula 78 M, very near the Equator, in *Orion* The only measures are by Sm, 32°·0 45″·0 (1836·8), but his observations of stars of this class are so uncertain that the evidence of change is too slight to be regarded

No 561 L 10969

Observed at first for H 5465, one of H.'s suspected pairs Subsequently the latter (L. 10989) was examined, but no trace of the suspected 12″ companion

No 562. L 11127

Near θ *Aurigæ.* Not much doubt of the duplicity of this star, but difficult and not well seen In L 7 m, and 7·3 in Arg (*See Note on last page.*)

No 566 *Monocerotis* 21.

In Lalande 6 m. and Bode 7 m. My estimate perhaps too low

No 567 *Monocerotis* 23.

Near the last. In Lalande 6 m, Bode 7 m., and Schj 8 m

No 568. *Canis Majoris* 33.

Estimated distance 1″; the measured distance may be too large.

No 570 11 *Monocerotis.*

A fourth star added to the well-known triple, Σ 919. Mean of three measures.—

P = 56°·1 D = 25″·79 1878·0.

No 573. L. 13642

In L, 6½ m, but not in the other Star Catalogues I failed to make any measures of this, but it has been observed by others as follows:—

	°	″	
De	P = 246.9	D = 0.81	1878.2
O S	244.9	0.8±	1878.2

No 575. *Canis Majoris* 156 (A and C = Σ 1057.)

The large star of Σ 1057 found to be double Magnitude of C from Σ The following are all the measures of the wide pair —

	°	″	
Σ	P = 1.9	D = 15.28	1831.2
β	2.1	15.87	1878.1

No 579 OΣ 173 *rej*

A and C, with another more distant star, make OΣ 173 It was rejected in the revised edition of 1850 of the Pulkowa Catalogue, as it exceeded in distance the limit adopted of 16″ In April 1875, when examining this pair with the 6-inch, I suspected the principal star was double, but failed to verify it later. The measure of C is by single distances and probably too small —

	°	″		
De	P = 233.6	D = 18.24	1869.7	AC
	347.3	43.12	1867.9	AD

It is 1° 15′ *s* of *Castor*.

No 580. *Pollux*

The three distant stars, C, D, and E, have long been known (= Σ 5 App II = H VI 42 = S 559) The nearest of these was found to be a moderately close and very unequal pair, and is one of the most difficult objects of that class in this list It was better seen during the second measure No small aperture will be able to deal with it satisfactorily. The small star, B, is much nearer the principal star than any hitherto measured. Only single distances of this and first measure of C. The larger of the three distant stars, E, has been measured as follows:—

	°	″	
Σ	P = 73·9	D = 203·84	1836·3
Dē	74·9	222·21	1865·3
Flm.	75·2	228·9	1877·1

For C we have:—

	°	″	
♅	P = 65·9	D = 116·7	1781·9
S	66·4	132·3	1825·1
Flm	72·1	175·0	1877·1.

The change is due to the proper motion of the large star.

No. 582 (A and B = Σ 1179.)

The wide pair is Σ 1179, to which a minute companion, C, is added. The distance of AB is increasing.

	°	″	
Σ	P = 205·2	D = 17·91	1829·7
Dē	204·6	19·13	1864·3
β	204·5	19·75	1878·1

No. 583 L. 15959.

Found in looking for the missing pair, ♅ II 87, the place of which, according to ♅, is $5^m\ 18^s$ *f.* this, with same declination. ♅ gives only an angle of 176°·2; so the two cannot be identical unless there is considerable motion in angle. It is too close now for his Class II. This pair has been measured at Cincinnati and Gallarate as follows:—

	°	″				
O S	P = 68·4	D = 1·75	Mags	9·0	9·8	1878·16
Dē	67·5	1·71		9·5	10·0	1878·26

No. 584. P VIII. 124 (ACD = S. 571.)

This is the principal star of the wide triple in *Præsepe*, South 571. These stars are relatively fixed.

		°	″	
A and C	S	P = 157·0	D = 45·03	1825·1
	De	156·8	44·97	1874·0
A and D	S	241·0	92·25	1825·1
	De	241·9	92·71	1874·0

De. gives the magnitudes of the large stars, 7·0, 7·2, and 6·50 respectively.

No 585 *Cancri* 109 (= B.A C. 2927)

A very close and difficult pair in the outskirts of *Præsepe*. The second measure was made with a power of 925, and the components well seen. In Lalande this star is 7 m, and 8 m in B A.C

No 587. 15 *Hydræ*.

This star, with the two distant companions, C and D, is ♅ V 120. ♅ gives 340° ± : 43″·03 (1783·0) for the nearer There are no other careful measures Smyth calls the magnitudes 12 and 13 respectively. The close pair is an exceedingly difficult object Observed twice at Cincinnati as follows —

	°	″	
O S	P = 163·5	D = 0·25	1878·16
	165·1	0·46	1878·22

No. 594 *Leonis* 150

This is L. 20111 (7 m.) Measured by De. as follows:—

	°	″			
Df	P = 141·8	D = 1·55	1878·33	Mags 6·5	11·0

No. 595.

About 15′ *n* of Σ 1474. Not in any Star Catalogue I have

No. 599. p^3, 65, *Leonis*

A fine and only moderately difficult pair. The mean result is:—

	°	″	
β	P = 82 4	D = 1 78	1878 2

No. 600. *Crateris* 36 (And C = ♅ N 26 = SH 120)

The principal star of this wide pair has an extremely minute companion Not seen well enough to measure on any subsequent occasion. It is certainly smaller than 12 m With very good definition on April 29, I could not be sure of it. There appears to be some change in the distant star The following are all the measures .—

	°	″	
SH	P = 97 6	D = 67 06	1823 4
β	97 3	61 53	1878 1

HEIS gives this as a naked-eye star, 6–7 m

No. 601 (A and B = ♅ IV. 112 = S. 627)

The smaller star of this wide pair is double, not very difficult, but too unsteady for measurement on the other nights It is difficult to reconcile the measures of distance of the wide pair. The following are all the recorded measures —

	°	″	
♅	P = 148 7	D = 26 25	1783 0
S	330 7	29 96	1825 2
β	331 6	28 16	1878 3

No. 603. *Leonis* 472

A large star *sp* β *Leonis* KN gives the angle and distance from β *Leonis*,

	°	″	
KN	P = 201 5	D = 1134 3	1864 4

In B A C , 6½ m., but not a naked-eye star according to HEIS A fine, and not difficult pair

No 605 *Corvi* 26 (= B A C 4149)

A comparatively easy pair near ζ *Corvi*. In B A.C , 6½ m., and 6 m in LALANDE, but not in HEIS.

	°	″			
O S.	P = 137 4	D = 0 99	1878 22	Mags 6 0	8 2

No. 607. SCHJELLERUP 4572.

A pretty little pair in a low-power field with γ *Virginis*, 37^s almost exactly *p*. In ARG , 9 2 m The mean result is :—

	°	″	
β	P = 315 8	D = 1 16	1878 2

No 608. 15 *Canes Ven*

15 and 17 *Canes* make the wide pair, Σ 24 App I. This appears to be relatively fixed, or but little changed.

	°	″	
Σ	P = 297 5	D = 289 98	1835 7
DE	297 3	288 30	1865 2

The new companion is not at all difficult The two measures give.—

°	″	
P = 284 9	D = 1 22	1878 3

No. 612. B A C. 4559

A very difficult close pair Stars just in contact with eye-piece IV. Professor HALL has measured this on two nights with the Washington 26-inch. The mean results are:—

		″	
HL	P = 57 7	D = 0 28	1878 43
β	56 1	0 23	1878 33.

A few minutes after making the third measure, Σ 1879 was observed, and that pair was certainly double the distance of this. ARGELANDER and HEIS give this 5 m

No. 613

The *p* star of a wide pair (84° 3 49″ 1) $12^s 4$ *f* the 6 m. star B.A C. 4628

No. 614. OΣ 271 *rej.*

This star was marked "oblonga ?" in the first edition of the Pulkowa Catalogue, but rejected as single in the revised edition of 1850 The only measures or attempted measures are the following by Ma. :—

°	″	
P = 144 2	D = 0 2	1843 3
130 2	0 22	1849 7

In April 1876, I examined it with the 6-inch and suspected an elongation in the direction of 150°. The large instrument brought out an excessively difficult companion, which probably has nothing to do with the preceding observations With a power of 925, which widely separated the components, the larger was perfectly round It is L. 25572, and the south star of three in a low-power field (*Astr. Nach.* 2199)

No. 617.

The wide pair is S 663, and also ♅ VI. 117, but there is an error of − 16′ in the declination of ♅. The following are all the measures of A and B :—

	°	″	
S	P = 219 1	D = 56 69	1825 3
β	219 5	59 44	1878 3

The principal star is L 26952.

No 618. ι^1 *Libræ.*

The wide pair is ♅ VI. 44 and Sh. 376. The small star is itself double, somewhat resembling μ^2 *Herculis.* There seems to be change in the distance from the primary, but the measures are conflicting :—

	°	″	
♅	P = 112 5	D = 59 07	1782 3
Sh	111 6	50 63	1822 8
β	110 5	57 46	1878 3.

Should distance of Sh. be 58″·63?

A mean of my measures of B and C gives —

β P = 24°.3 D = 1″.86 1878.3

No. 619. *Serpentis* 55.

A fine close pair. My second distance is certainly too large. The real distance is probably less than 0″.4.

No. 620. (A and C = H. 4803.)

The description in H of the wide pair is:—

H P = 214°.8 D = 40″.± 1836.7 Mags. 8 9

The large star is itself double. The direction of C is apparently unchanged.

No. 625. ω *Herculis.*

A pretty pair, and not difficult. The companion was seen at Denver, Colorado, with the 6-inch, which was taken to that point to observe the total eclipse of July 29. The observation was made at an altitude of about 5,200 above the sea, and in a locality remarkable for the purity of its atmosphere.

A mean of the measures gives:—

β P = 175°.3 D = 1″.90 1878.6

No. 627. 52 *Herculis*

A fine, easy pair. The mean of the five measures is —

β P = 309°.4 D = 1″.83 1878.4

No 628

A rich neighbourhood for double stars, near 68 *Herculis* This pair, and the two following (Nos 629, 630), OΣ 328 and β 45, are all in the same vicinity

No 631. *Ophiuchi* 255 L 32200

A close equal pair, for which the two measures give —

	°	″	
β	P = 70·2	D = 0·36	1878·5

No 632 L. 32600. (A and C = OΣ 336 *rej*)

A much nearer companion detected than that known heretofore The following, which are all the measures of the wide pair, seem to show a small diminution in distance:—

	°	″	
Ma	P = 164·0	D = 44·66	1843·3
De	164·9	43·19	1866·9
β	164·9	42·80	1878·4

The magnitudes of A and C are from De.

No 633 γ *Draconis*

All very faint companions There are two more distant and larger stars having about the same position angles as C and D Edgecomb saw B readily with a 9·4-inch Clark refractor without any intimation in regard to the direction

No 634 o, 67, *Ophiuchi* (AC = ♅ VI. 2 = Sh 255 = OΣ (App) 162)

The nearest star, B, not mentioned by ♅, is found in the Munich Observations, with measures from C:—

	°	″	
Mu	P = 265·1	D = 30·3	1836·7

In measuring this a very faint attendant to the old companion was detected. The large stars, AC, are relatively fixed:

	°	″	
Sh.	P = 141·3	D = 55·23	1823·3
Ds.	142·8	54·79	1874·0
β	143·0	54·70	1878·6.

No. 638. (A and B = Σ 2287 *rej.*)

The only prior measure of the wide pair is found in the Washington Observations for 1862:—

	°	″	
Hl.	P = 150·8	D = 22·22	1863·6
β	152·0	22·33	1878·0.

The close star is small and difficult.

No. 639. L. 33642. (A and C = Sh. 264; C and D = β 300.)

In 1874 I found a very minute star near C, estimated 330° : 4″. Looking for this on the present occasion, I noticed the larger star of the wide pair was a close double. The images were very unsteady and the measures are very discordant. The first distance is certainly too large. I could not see D. There appears to be some change in the distance of the wide pair:—

	°	″	
Sh.	P = 52·6	D = 16·42	1823·5
Hl.	51·5	16·83	1863·7
O.S.	52·4	17·49	1876·6
β	51·7	17·30	1878·6.

No. 642.

The principal star of the cluster, H.G.C. 4420. The larger is decidedly reddish.

No. 643. *Tauri Pon.* 55. (A and C = Σ 2342.)

A much nearer star than that measured by Σ, and rather difficult. By three measures we have:—

	°	″	
β	P = 338·2	D = 8·86	1878·2.

A slow, apparently rectilinear, movement in B:—

	°	″	
Σ	P = 11·9	D = 26·91	1830·7
De	9·3	28·13	1865·1
Gl	9·3	28·62	1874·8
β	7·8	28·80	1878·0.

No 647.

The distances, in consequence of the condition of the micrometer at the commencement of my work, are only approximate. I have been favoured with two measures by De, and the following is the mean:—

	°	″	
A and B	P = 11·5	D = 1·01	1877·7
A and C	215·8	19·56	1877·7

No 648. B.A.C 6480.

This fine pair is a naked-eye star very near γ *Lyræ*, 6 m. in Heis. The difference in the magnitudes of the components, and their distance, make it a difficult pair. The mean of the two observations is:—

	°	″	
β	P = 312·5	D = 0·61	1878·5

No. 649.

This pair of small stars is 13′ *s.* of γ *Lyræ*. The measures give:—

	°	″	
β	P = 12·8	D = 1·57	1878·5

No. 651.

An unequal pair 19′·5 *n.* of β *Cygni.*

No 652. (A and C = ♅ II. 99 = S. 718 = Σ 2539.)

An excessively minute star, a little nearer than the old companion. The measures were made with some difficulty. A and C are relatively fixed.

No. 653. *μ Aquilæ.*

Two very faint companions forming a pair. The distance of BC is uncertain for the reasons already given.

No. 654. *h*^{2}, 52 *Sagittarii.*

But for its southern declination this would be a very easy pair The three measures give:—

	°	″	
β	P = 160·8	D = 2·93	1878·6

No. 655 (ABC = Σ 2549.)

The new star makes, with one of Σ's companions, a difficult pair. The relations of the large stars have changed considerably. The following are all the measures:—

		°	″	
AB	Σ	P = 278·8	D = 47·48	1832·2
	De.	277·1	49·07	1863·5
	β	276·7	49·79	1878·5
AC	Σ	291·3	21·12	1832·2
	De	289·5	22·38	1863·5
	β	289·4	22·86	1878·5.
BC	Σ	89·0	26·88	1832·2
	De	87·1	27·48	1863·5
	β	85·9	27·63	1878·5

No. 656. L. 37475.

This close pair has been measured once by De., and the observation, with a mean of my measures, is as follows:—

		″	
De	P = 261·0	D = 0·48	1877·8
β	257·6	0·50	1878·2

No. 665 γ *Cygni.*

A very distant double companion. The results are .—

	°	″	
A and BC	P = 196·5	D = 140·44	1878·0
B and C	305·1	1·41	1878·5

No 666.

Measure of distance doubtful It has been observed by De. as follows:—

	°	″		
De	P = 124·7	D = 2·00	1877·8	Mags 9·0 . . 12·0

No. 668 B A C 7080

A naked-eye star, 6 m. in Heis The mean result of the three measures is:—

	°	″	
β	P = 29·0	D = 4·64	1878·6

No. 669. ω^2 *Cygni*

The nearest companion is very faint.

No. 670.

About 50^s *p* this is H. 1527, a 3″ pair of 10 m. stars. The new double is the southern star of a wide pair. It has been measured once by De.:—

	°	″	
β	P = 58·3	D = 0·76	1877·75
De	53·5	0·63	1877·83.

No. 671.

This is the *sp.* of two similar stars. It has been measured by De., and the two observations stand:—

	°	″		
β	P = 334·8	D = 0·5±	1877·6	
De.	335·9	0·47	1877·9	Mags. 8·0 . . 8·5.

No 673

The *n.* star of a wide pair. The other is Arg. (20°) 4682, 1^s 4 *f* and 1′ 6 *s.*

No 675. 51 *Cygni.*

The close star, B, is exceedingly minute, and under ordinary circumstances rather difficult. The measures give:—

	°	″	
β	P = 101 5	D = 2 78	1878 2

C and D are brighter, and readily seen.

No. 679

Without doubt this is the most minute close pair known, and is worth noting as a curiosity in double stars, if for no other reason It is too small to be found even in Argelander The place was determined from Arg. (43°) 3802, an 8 8 m star in a low-power field, *sp* The magnitude of the double would be perhaps more nearly 1 1 than 10. It is near ξ *Cygni*

No 680

One of a wide pair of equal stars, the other about 25″ distant in 34° 5. De has measured the close pair twice, the mean result of which is:—

	°	″	
De	P = 129 5	D = 0 63	1877 7

No 681 Rumker 9004

The three measures result as follows·—

	°	″	
β	P = 239 7	D = 2 51	1878 7.

No. 686 (A and B = OΣ (App.) 220.)

The close pair has been measured twice by De., from which it would seem my angle is decidely too small, possibly an error of 10°:—

	°	″		
De	P = 127 9	D = 0 38	1877 7	Mags 7 7 . . 8 0
β	117 5	0 4	1877 6,	

No 688. R. 5364

A close pair *sf.* 77 *Cygni.* The mean of four measures is —

β P = 209°·2 D = 0″·38 1878·1

No 689 *Aquarii* 88

The mean of three measures gives —

β P = 240°·5 D = 1″·80 1878·0

No. 690 *μ Cephei.*

The celebrated "garnet star" of H, variable from 4 to 6 m in five or six years. It is No 253 of Schjellerup's Catalogue of Red Stars. There is another star in the direction of 190°·8 They are all faint objects The two measures of AB give :—

β P = 259°·8 D = 19″·27 1878·5.

No 693. L. 42730.

For the mean of three observations we have :—

β P = 54°·1 D = 0″·93 1878·4

No. 694. *Lacertæ* 4.

A fine close pair, and moderately difficult. The two measures give:—

β P = 352°·3 D = 0″·50 1878·7

In B.A.C. 6 m., and Arg. 6·5 m.

No. 696.

The *s.* star of a small triangle. De. has measured twice, reversing the angle:—

De. P = 175°·2 D = 0″·50 1877·8 Mags 8·0 . 8·0
β 353·8 0·65 1878·2.

No. 699

In the vicinity of Σ 2878. The three measures give:—

	°	″	
β	P = 187·3	D = 2·04	1878·4

No 700

In the field with OΣ (App) 234, 27^{s} *p.* and 1′ *s.* Dᴇ has the following measure .—

	°	″	
Dᴇ.	P = 332·4	D = 10·33	1878·7

No 701 L. 43867

This difficult pair has been measured twice by Dᴇ The mean results are as follows:—

	°	″			
Dᴇ.	P = 283·4	D = 1·24	1877·8	Mags 7·0	9·0
β	280·0	1·24	1878·2	7·5	10·0

No. 702. δ *Cephei* (AC = Σ 58 App. I. = ♅ V. 4 = Sʜ. 347 = OΣ (App) 235)

A faint star nearer than the old companion. The measures give —

	°	″	
β	P = 285·7	D = 19·37	1878·6

The large stars appear to have a common proper motion, as their relations are unchanged.

	°	″	
Σ	P = 192·0	D = 40·87	1835·1
β	191·9	40·88	1878·6

No. 709.

Near Σ 2938 Not in any Star Catalogue I have, and place found with micrometer from L. 44461. The three measures give:—

	°	″	
β	P = 8·9	D = 2·04	1878·2.

No. 710

A difficult pair of small stars, 30′·3 *s.* of *η Pegasi*, and 26^s *f.*

No. 712.

This has been measured once by DE.:—

	°	″				
β	P = 291·6	D = 1·02	1877·6	Mags	9·0	9·5
DE	290·4	1·14	1877·7		9·7	10·2

No. 713 (A and B = Σ 2959.)

A very minute star near B. It was missed in the first measure. There is a decided change in the wide pair, as will be seen from the following:—

	°	″	
Σ	P = 96·7	D = 15·66	1832·1
MA	97·8	14·88	1843·6
DE	101·7	14·21	1864·8
β	102·2	13·77	1878·8.

No. 715. *Aquarii* 290.

This pair has been observed once at Cincinnati. This, and the mean of my four measures are given below:—

	°	″	
O. S.	P = 258·0	D = 3·47	1877·8
β	256·0	3·35	1878·3.

No. 716.

A pretty pair of very small stars in the field with ψ^1 *Aquarii* (Σ 12 App. II.), 15^s *p.* and 60″ *n.*

No. 717. 8 *Andromedæ.*

The companion is faint, but it is not a difficult object under good conditions. The mean result is:—

	°	″	
β	P = 161·4	D = 7·61	1878·2.

No. 718. 64 *Pegasi*

A fine close pair, and difficult from the considerable inequality in the magnitudes of the stars. It is rather more troublesome to observe than 72 *Pegasi*. The mean of three measures gives:—

β	P = 86°·9	D = 0″·46	1878·7

No. 720. 72 *Pegasi*

A close pair of equal stars, discovered a few minutes after the preceding. It is widely separated with the higher powers. The seven measures give as a mean:—

β	P = 127°·7	D = 0″·40	1878·7

No. 723. L. 46375

The following is the mean of four observations:—

β	P = 168°·5	D = 3″·78	1878·2.

No. 725. L. 46464.

Measured once by O. S.

β	P = 237°·3	D = 4″·30	1877·8
O. S.	245·3	4·46	1877·8.

No. 726.

Not in any Star Catalogue I have. It is about 50′ *s.* of the naked-eye star, B.A.C. 8266.

No. 730. 27 *Piscium.*

This is quite an easy pair. The three measures give:—

β	P = 265°·8	D = 1″·42	1878·4.

No. 732.

The north star of a wide pair:—

β P = 152°·4 D = 6″·10 1878·3

No. 733. 85 *Pegasi*.

A very interesting system from the large proper motion and sensible parallax of the principal star. The latter has been investigated by BRUNNOW (*Dunsink Observations*, 1873) by micrometrical measures of A and C, from which he finds the parallax to be 0″·054. It is not found in any Double Star Catalogue. This is partly accounted for by the fact that at the time of the observations of H and Σ the distance between A and C was too large to bring them within the limits usually adopted.

FLM has given this system special attention, and it was at his request that the series of measures here given was commenced. The wide pair was observed three times before the close star was detected, although on each occasion the field was examined with reference to any new member which might exist. These nights, however, were not sufficiently favourable for so difficult an object as the new star. The last night on which C was measured was unusually fine. A short time before on the same evening 64 *Pegasi* and 72 *Pegasi* had been discovered, and a little later η *Piscium* and B.A.C. 1101 were added to this list, all of them being difficult objects of the first class. The small star, B, was then noticed, and an excellent measure obtained. It has been measured since on every available night, but opportunities have been rare when it could be satisfactorily seen. The mean result of the three measures thus far made is:—

β P = 274°·0 D = 0″·67 1878·7.

It is evident that an examination a few months hence, even without measures, will show at once whether there is any physical connection existing, since the change due to proper motion would otherwise be very apparent in so close a star.

The measures preceding my own of the wide pair are taken from proof sheets of a most valuable and interesting work by **Flm**, "Catalogue des Étoiles Doubles et Multiples en mouvement relatif certain," now in the press. The angle and distance by **Argelander** are deduced from differences of R A and Decl :—

	°	"	
Arg	P = 105 0	D = 30 0	1855 00
Brunnow	77 0	16 00	1870 00
Flm	49 8	14 0	1877 94
β	33 6	14 40	1878 54

The minimum distance was reached in 1877, about the time of the observation by **Flm**, and the stars are now gradually separating **Flm** gives the proper motion of A as follows :—

	s		"
R A.	+0 064	Decl	−0 97

Brunnow thinks C has also a small motion in space.

New Nebulæ.

The places given in the Catalogue are those of the stars from which the nebulæ are measured The first is in the field with a 7 m. star, L. 6634 (6 m in L) The other is still nearer the naked-eye star B.A C 4396. They are not very faint. The measures indicate the distance and direction from the respective stars. They are not found in **Herschel**'s General Catalogue, nor in the supplementary Catalogue by Dr **Dreyer**.

II —*Micrometrical Measures of* 500 *Double Stars*

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
1	Σ 3063	W¹ xxiii 1234	0 1 28	− 5 13	221 8	1 71	8 3	10 2	7 829	
					224 8	1 92	•		7 942	
2	H 1939		0 3 41	10 45	159 1	36 08	7	10	7 807	
3	Hd 1	W¹ 0 57	0 5 6	7 17	119 6	12 80	7 5	17	7 829	Difficult
4	Σ 14	W¹ 0 134	0 9 42	−12 39	236 2	14 50	8 3	11 0	7 942	
					236 4	14 27			7 953	
5	Σ 15		0 9 43	− 6 16	197 2	4 61	7 5	10 0	7 942	
6	OΣ 4	L 220	0 10 26	35 49	155 3	0 56	7 5	7 8	8 657	
7	β 392	B A C 46	0 10 31	60 52	69 4	19'43	6 0	12 0	8 671	
8	H 1951	W¹ 0 189	0 12 41	−11 37	216 6	24 09	8–9	15	7 947	H 215° 4 16″ ±
9	H 1953	ι Ceti	0 13 19	− 9 30	16 5	61 89	4	12	7 942	H 14° 2 45″ ±
10	Schj 1		0 20 45	− 6 11	27 8	25 00	8 7	9 5	7 862	No other measures
11	Σ 35		0 25 27	− 2 43	266 6	8 62	9 4	9 6	7 947	
12	De 2	W¹ 0 459	0 28 22	− 5 12	241 8	0 89	6 9	7 7	7 818	A and B
13	H 1993	α Cassiopeiæ	0 33 42	55 53	110 7	39 94			7 573	A and B
					106 7	40 20	B = 13–14		8 647	
					280 0	62 25			7 573	A and C
					279 8	62 51	5–6	14	8 647	
14	Σ 49		0 34 42	− 7 53	320 8	5 58	6 5	10 0	7 862	
					320 8	5 78			7 876	
15	Σ 18	L 1118	0 36 11	3 31	116 1	1 39	7 3	9 0	7 947	
16	β 231	o Cassiopeiæ	0 38 2	47 38	303 7	32 16	5½	12	8 471	De 303° 9 32″ 81 (1876 5)
17	Hd 8	W¹ 0 715	0 42 28	− 2 25	38 1	6 85	8	11	7 876	Mags 9 0 10 0
18	Σ 68		0 45 46	− 8 49	296 0	7 58	8 0	10 0	7 876	No change
19	Σ 67	L 1432	0 45 52	9 57	10 8	1 52	8 3	9 0	7 953	Probably fixed
20	Hd 10	W¹ 0 802	0 47 17	2 39	232 3	1 09	9		7 862	Mags 9 9+
21	H 1057	μ Andromedæ	0 50 6	37 51	316 6	36 51	B = 13–14		8 529	A and B
					314 0	38 05		12	8 742	
					312 6	37 25		13	8 747	
					116 7	39 26	4	16	8 529	A and C
					117 0	38 09			8 742	
					117 1	37 55			8 747	
22	Σ 76		0 50 19	10 1	200 1	2 84	8 8	11 5	7 953	
23	H 1064	39 Andromedæ	0 56 10	40 42	0 9		6	15	8 638	Clouded before distance
24	β 396	B A.C 282	0 56 13	60 26	66 6	1 ±	6	10 5	8 660	Clouded before distance
					69 1	1 14	6 5	11 0	8 796	Unsteady

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
			h m s	° ′	°	″			
25	H 1068	72 Piscium	0 58 44	14 18	263 1	54 81	5–6 18	7 818	
26	OΣ 515	φ Andromedæ	1 2 32	46 36	273 0	0 2	5 6 7	7 739	
27	β 235	L 2042	1 3 27	50 22	76 9	0 84	7 8 7 8	8 647	A and *a*
					76 6	8 50	9 12 0	8 647	B and *b*
					47 2	8 13	9 11 0	8 647	C and *c*
28	Σ 95		1 4 24	– 5 36	309 6	14 18	8 5 9 7	7 859	
29	OΣ 28	R 378	1 8 13	80 16	314 0	0 85	6 8 8 2	8 660	
30	H 1076	W^1 1 118	1 9 50	13 6	163 0	14 16	9 17	7 859	A and B
					258 2	41 1	14	7 859	A and C
31		Polaris	1 13 45	88 40				8 151	
32	H 637	W^1 1 237	1 16 28	– 4 26	168 3	25 92	7–8 15	7 845	No measures in H "very delicate"
33	β 4	W^1 1 236	1 16 34	10 44	81 0	0 37	7 7 5	7 717	No other measures
34	H 1079	44 Ceti	1 18 0	– 8 38	299 6	76 40	6 12	7 862	H. 300° 5
35	OΣ 30	L 2561	1 18 54	30 55	238 9	4 55	7 3 11 7	7 736	B and C
36	Σ 132		1 25 35	16 20	354 6	33 86	7 0 10 0	8 014	
37	OΣ 32	R 467	1 30 49	84 37	133 7	8 79	7–8 12	8 660	
					134 2	9 06		8 668	
38	Σ 145	P I 145	1 34 36	25 8	31 9	11 38	6 0 10 6	7 725	
					32 2	11 55		8 711	
39	Σ 196	P I 122	1 52 55	20 26	51 8	2 62	8 5 11 0	7 666	
					52 1	2 36		7 856	
40	Σ 201	ε Trianguli	1 55 58	32 42	116 8	4 10	5 3 11 3	7 810	
41	OΣ 38	γ Andromedæ	1 56 32	41 45	102 7	0 48	5 0 6 2	8 655	B and C
					101 5	0 39		8 657	
42	H V 102	61 Ceti	1 57 39	– 0 55	193 3	42 71	7 11	7 862	A and B
					326 3	80 4		7 862	A and C
43	Σ 223	O^2 Arg 2486	2 6 9	80 10	50 7	0 78	8 0 10 4	8 660	
44	Σ 242 *rej*	Ceti 346	2 10 20	–10 23	228 5	50 54	6–7 10	7 939	Mags 7 0 9 0
45	β 437	L 4291	2 12 26	3 39	33 4	7 08	8 12–13	7 942	
					31 5	7 24		7 953	
46	H VI 1	*o* Ceti	2 13 17	– 3 31	91 5	74 11	2–7 13	7 818	A and B
					82 8	115 62	10	7 818	A and C
47	Σ 290		2 33 13	– 2 25	220 6	10 25	8 1 10 1	7 698	Fixed
48	Σ 295	84 Ceti	2 35 4	– 1 12	324 3	4 73	6 0 9 2	7 953	
49	Σ 293		2 35 31	56 33	75 3	8 30	8 5 11 7	8 647	
50	Σ 303		2 38 35	– 2 28	181 9	5 87	8 5 9 5	7 859	
51	β 307	L 5133	2 40 29	29 11	315 4	14 91	7 11 5	7 725	
52	Ward	η Persei	2 41 56	55 24	268 3	67 03	4 10	8 151	A and C, AB = Σ 307
					116 0	5 06	10 12	8 151	C and D
					112 3	5 29	9 5 12	8 776	Unsteady

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
53	Σ 310		2 42 7	33 26	87 6	2 62	7 7	10 9	7 870	
54	OΣ 46	L 5205 .	2 42 45	30 2	167 5	20 66	7	19	7 725	A and C
55		τ Persei	2 45 45	52 16	106 0	50 08	5	12	8 151	A and B }
					106 8	51 27		12	8 780	}
					75 3	4 ±		13	8 151	A and C }
56	Σ 330	Ceti 478	2 51 3	− 1 3	191 1	9 02	7 5	9 5	7 862	
					191 9	8 36			7 939	
57	Σ 332	W¹ ii 878	2 51 41	− 0 4	52 7	12 52	8 5	8 5	7 859	
					54 1	12 52			7 931	
58	Σ 333 .	ε Arietis .	2 52 21	20 52	197 6	1 56	5 7	6 0	7 725	
59	Σ 355		3 0 54	7 56	147 8	2 64	8 7	9 5	7 939	
60	Σ 356		3 1 0	−13 47	13 3	15 59	7 7	10 8	7 829	No change
61	Σ 358	W¹ ii 1091	3 2 44	− 4 9	350 3	14 39	8 5	11 3	7 947	
62	β 400	W¹ iii 50	3 5 18	− 4 16	53 2	21 69	7	11 5	7 947	
63	H 663	94 Ceti	3 6 37	− 1 39	250 9	5 73	5	19	7 698	
64		τ¹ Eridani	3 14 12	−22 12	99 3	39 97	3½	11	7 810	A and C
65	Σ 406		3 24 28	4 45	124 2	9 65	7 0	9 0	7 939	No change
66	Σ 430	Tauri 39 .	3 34 8	4 44	55 4	26 43	6 0	9 0	8 030	A and B }
					301 0	37 74		9 8	8 030	A and C }
67	Σ 431	40 Persei	3 34 46	33 35	238 0	19 98	4 2	9 5	7 882	Fixed
68	OΣ 61 *rej*	L 6847 .	3 36 18	7 31	127 8	1 87	7 2	10 0	7 942	
69	Σ 449 .		3 40 17	24 17	330 1	7 05	8 5	11 0	7 870	
					331 5	6 83			8 096	
70	Σ 453	Atlas Pleiadum .	3 42 1	23 41					8 657	Single
71	H 338	30 Eridani	3 46 47	− 5 43	135 3	8 34	5	17	7 966	
72	Σ 475		3 52 3	− 7 28	22 5	7 34	8 2	10 6	7 862	
73	H 3608	γ Eridani	3 52 24	−13 51	238 0	51 0	3½	13	7·698	Single distance
					238 5	51 79	.		7 942	B 12–13 m
					238 6	52 07			8 003	H 233° 6 · 45″ ±
74	OΣ 531	B A C 1264 .	3 59 34	37 46	138 7	2 63	6 7	8 9	8 655	
					138 4	2 57			8 671	
75	Σ 497	.	4 2 3	8 8	235 2	14 16	8 5	10 7	7 939	Hazy
76	Σ 499		4 2 32	23 45	285 6		9 2	9 3	8 093	A and B } Too poor for distance
					281 1	29 92	11 2		8 093	AB and C }
77	OΣ 73	μ Persei	4 6 5	48 6	348 6	14 88	4–5	12	8 151	B = 12–13 m
78	OΣ 77	L 7899	4 8 17	31 24	244 4	0 37	7 8	7 8	8 030	
					245 4	0 54	.		8 655	
					254 5	0 40	.	.	8 657	
					253 0	0 46			8 675	
79	Σ 518	40 Eridani .	4 9 52	− 7 47	129 0	3 64	10	11	7 701	B and C
					129 3	4 05			7 810	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
					126 8	4 08			7 818	
					126 5	3 94			7 829	
					129 8	3 83			7 942	
					129 2	3 98			7 953	
					127 1				7 966	Clouded
					146 0	38 01			7 701	A and *d*
					145 5	36 87			7 818	
					145 4	36 43			7 829	
80	β 402	W¹ IV 318	4 17 3	− 1 33	74 0	6 94	8 5	10 5	7 947	
81	H 349	W¹ IV 327	4 17 18	− 5 17	234 5	17 33	9	10	7 953	A and B } Mags 7 5, 9 0, and 12–13 , no measures by H
					84 3	28 73		17	7 953	A and C
82	Σ 547	W¹ IV 383	4 19 48	− 1 40	8 7	2 45	8 5	11 5	7 947	
					10 8	2 47			7 953	
					10 0	2 01			8 063	
83	Σ 554	80 Tauri	4 23 17	15 23	7 0	0 60	6 5	9 0	8 030	
84	Σ 571		4 30 3	− 3 51	258 2	17 30	6 3	11 0	8 003	
85	Σ 596		4 40 15	−12 10	287 2	10 95	8 0	10 2	7 942	
					287 5	10 56			8·003	
86	Σ 609		4 43 40	0 59	74 7	2 84	8 5	8 7	8 093	Very unsteady
					76 5	2 57			8 096	
87	Σ 607		4 45 47	25 14	250 6	14 34	9 0	10 8	7 870	
					249 7	14 05			7 947	Mags 9 0 11 0.
					250 5	13 97			8 099	
88	H 3700	O¹ Arg 3467	4 48 1	−20 58	347 8	26 20	7	14	7 942	H 345° 3 20″ ±
89	OΣ 92	5 Aurigæ	4 52 3	39 13	247 4	2 78	5 7	9 8	8 041	
90	Σ 639		4 58 0	− 3 2	79 3	5 35	8 2	9 0	8 003	Probably fixed
91	OΣ 100	W¹ V 15	5 3 28	8 2	248 8	3 80	7 0	10 2	8 093	
92	OΣ 517	L 9802 .	5 7 14	1 50	137 6	6 20	6 2	13	8 093	AB and C
93	H I VI 30	α Aurigæ	5 7 49	45 53	183 2	126 2			8 036	A and B } Single distances B = 12–13 m
					146 2	158 6			8 036	A and C
94	OΣ 103	16 Aurigæ	5 10 17	33 14	54 3	3 96	5 0	10 7	8 655	
95	β 188	τ Orionis	5 11 47	− 6 58	62 1				7 810	B and *b* }
					49 5	3 53			7 829	
					52 1	4 49			7 947	
					50 3	4 13			8 153	
					249 1	36 20	4	14	7 947	A and B
					60 0	36 09		12	7 947	A and C
96	β 190	Orionis 82	5 14 38	− 8 9	2 9	0 50			8 091	A and B Well separated
97	Ma 1		5 15 32	− 6 57	159 5	3 01	9	9 5	7 862	A and B }
					137 7	34 6			7 862	A and C
98	Σ 693		5 15 37	− 2 10	12 5	3 87	8 7	9 0	7 942	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
			h m s	° ′	°	″			
99	OΣ 107	115 Tauri	5 20 10	17 52	308 4	10 18	6 0 11 0	7 870	
100	H 365	114 Tauri	5 20 26	21 50	346 9	37 80	5-6 17	7 870	A and B
					193 9	58 82	17	7 870	A and C
					279 6	74 29	17	7 870	A and D
101	β 320	β Leporis	5 23 6	−20 51	289 5	2 63	3 0 11 0	7 810	Mags from Do
					291 5	2 86		7 829	
					288 0	2 56		7 994	
					284 9	2 45		8 030	
					289 6	2 63		8 170	
					286 3	2 96		8 197	
102	Σ 728	32 Orionis	5 24 22	5 51	196 2	0 45	5 2 6 7	8 030	
103	II 3766	α Leporis	5 27 25	−17 55	154 8	36 02	3½ 12	7 953	
104	Σ 748	θ Orionis	5 29 23	− 5 28	354 1	4 20		7 873	Fifth star
					354 9	4 18		7 934	,,
					354 0	3 69		7 942	,,
					117 6	3 80		7 873	Sixth star
					120 8	3 61		7 934	,,
					121 1	3 82		7 942	,,
105	β 90	26 Aurigæ	5 30 56	30 25	113 2	25 86		7 870	A and C
106	β 321	Leporis 45	5 33 59	−17 55	140 1	1 11	7 0 8 5	8 170	A and *a*
					359 8	1 72	9 0 10 5	8 170	C and *c*
					136 0	87 85		8 178	A*a* and C*c*.
					136 2	88 82		8 197	
					31 8	51 33	10	8 178	C*c* and G
					48 7	60 3		8 170	A and E, single distance
					310 4	41 79		7 994	A and *x*
107	Σ 782	W¹ v 908	5 36 47	− 0 2	307 9	39 44	7 8 8 3	7 942	
108	β 192	τ Aurigæ	5 40 52	39 8	350 0	38 93	5 12+	7 824	A and B
					32 9	47 85	12	7 824	A and C = 𝕳 V 21
109	II 3279	133 Tauri	5 40 54	13 51	298 6	17 87	6 16	7 870	II 250° I 182°·0
					181 2	24 95	15	7 870	
110	OΣ 119	L 10974	5 41 24	7 55	314 0	0 61	7 7 8 2	8 030	
					316 8	0 77		8 170	
111	β 405	W¹ v 1045	5 42 22	−13 34	125 1	14 50	8 5 11 0	7 953	
112	β 406	W¹ v 1068	5 43 1	−13 28	243 1	12 01	9 0 12 0	7 953	
113	𝕳 V 90	ν Aurigæ	5 43 10	39 7	207 0	54 97		7 824	
114	De 10	Arg (29°) 1027	5 45 6	29 45	164 8	2 56	8 5 11·5	7 882	A and B
115	β 95		5 46 8	− 7 20	298 2	13 67	8 0 12 0	8 156	Near 55 Orionis
116		α Orionis	5 48 40	..	348 2	75 91	B = 12–13	7 942	A and B.
					348 8	78 68		7 953	
					346 9	78 17		8 003	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
			h m s	° ′	°	″			
117	S 503	W^1 v 1206	5 49 10	13 56	157 3	28 09	7 13	8 003	A and C
					167 8			8 003	B and C
118	OΣ 121	R 1582	5 49 49	74 0	185 3	0 32	7–8 8–9	8 151	Well separated
119	OΣ 545	θ Aurigæ	5 51 32	37 12	3 8	1 90	3 0 7 5	8 041	A and B
					292 7	45 51	10	8 041	A and C
120	H V 100	59 Orionis	5 52 10	1 49	205 8	36 57	6	8 178	H 37″ 25 (1783 0)
121	Σ 826	.	5 52 49	– 1 20	126 7	2 02	8 2 9 2	7 453	
					124 7	2 35		7 994	
122	Σ 848		6 1 42	13 59	295 4	15 55	7 3 12 0	8 003	A and *c*
123	β 96	75 Orionis	6 10 29	9 59	226 5	4 74	9 11 5	7 934	B and C
124	Σ 903		6 18 49	–12 54	294 3	22 73	7 0 11 0	8 189	Unsteady
125	Σ 910	P VI 105	6 20 36	0 31	162 5	0 93	8 3 9 0	8 197	B and C
126	Σ 938	14 Monocerotis	6 28 16	7 40	209 9	10 59	7 0 11 2	8 197	
127	Σ 943	Arg (23°) 1432	6 30 33	23 17	147 4	19 65	8 5 9 0	8 175	
128	H 397	W^2 vi 961	6 33 47	28 19	56 8	55 72	8 13	8 882	
129	Σ 951	W^1 vi 978	6 33 51	9 56	309 2	21 43	8 5 10 7	8 156	A & B No change
					229 2	11 56		8 156	B & C C found by Ward
130	Σ 955		6 35 24	– 7 53	272 2	1 00	8 7 9 0	8 063	A and B
					189 4	11 48	8 5	8 063	A and C
131	OΣ 154	L 12831	6 35 52	40 45	129 0	27 77	6 2 8 2	8 041	
132	OΣ 155	L 12941	6 38 1	24 48	261 0	15 23	6 8 10 5	8 091	
					258 5	14 92		8 175	
133	A G C 1	Sirius	6 39 53	–16 33	52 9	10 24		7 873	A and B
					54 0	10 68		7 934	
					53 4	10 34		7 942	
					52 6	11 36		7 947	
					53 0	11 13		7 994	
					51 9	11 32		8 030	
					51 3	11 19		8 036	
					50 2	10 70		8 041	
					113 5			7 873	A and C
					115 1	71 30		7 994	
					112 3	71 37		8 036	
					158 9	104 60		7 873	A and D
					158 5	103 32		7 994	
134	Σ 966	Arg (40°) 1729	6 41 52	40 5	111 7	5 35	8 2 10 2	8 041	No change
135	A C 4	Canis Majoris 89	6 43 32	–15 1	295 4	1 10	6½ 9	8 030	
136	OΣ 159	15 Lyncis	6 46 54	58 35	1 0	0 48	4 7 7 2	8 151	A and B
					31 4	23 64	12–13	8 151	AB and C
137	OΣ 160	L 13275	6 47 11	21 19	174 2	1 43	7 10	8 156	Difficult to-night
138	Σ 990		6 48 51	–14 6	273 1	3 41	8 7 9 3	8 156	No change

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
			h m s	° ′	°	″			
139	Σ 992	.	6 49 55	− 9 20	299 6	13 75	8 0 9 5	8 159	No change
140	OΣ 162 *rej*	41 Geminorum	6 52 57	16 7	155 8	21 41	7 10	8 170	
					153 9	20 55	.	8 189	Excessively unsteady
141		ε Canis Majoris	6 53 54	−28 48	160 2	7 42	2 9	8 219	
142	Σ 1014		6 58 20	26 19	38 9	1 82	8 7 8 7	8 057	Windy.
					36 3	1 88	.	8 063	Σ 32° 2 2″ 09 (1830 2)
143	OΣ 165	45 Geminorum	7 1 29	16 9	76 5	2 56	5 10–11	8 030	
					79 7	2 34		8 214	B = 12–13 m
144	Σ 1031	W¹ vii 22	7 3 2	−13 48	248 3	3 33	8 3 9 0	8 175	Poor seeing
145	Σ 1034	W¹ vii 37	7 3 35	− 8 7	18 7	2 64	8 7 9 2	8 088	Fixed
146	Σ 1058		7 10 3	9 37					No companion
147	Σ 1064	Canis Majoris 163	7 11 30	−11 49	239 6	14 96	7 0 9 7	8 088	
148	Σ 1074	.	7 14 21	0 38	146 0	0 71	7 8 8 2	8 030	
149	Σ 1071		7 14 22	45 14	7 3	16 24	8 2 . 10 2	8 041	
150	Σ 1081		7 17 1	21 41	226 1	1 36	7 8 8 5	8 091	
151	OΣ 172 *rej*	L 14465	7 21 34	35 3	245 3	12 ±	7 11	8 159	No prior measures
152		γ Canis Minoris	7 21 38	9 10	243 2	32 60		8 063	
153	Σ 1097	P VII 116	7 22 14	−11 19	313 5	20 21	6 0 . 8 7	8 159	AB and C
					157 3	23 35	9 8	8 099	AB and D
					157 2	23 47	.	8 159	
					41 4	31 06	12–13	8 159	AB and E
154	H 760		7 25 11	− 0 52	355 3	29 92	6 20	8 088	
155	OΣ 175	B A C 2489 . .	7 27 31	31 13	334 9		5 5 . 6 3	8 236	Too windy for distance
156		Procyon	7 33 1	5 33	316 9	44 71	. . .	7 810	
					317 6	44 53		7 953	
157	Σ 1142 .	... .	7 41 40	13 43	254 5	22 84	8 0 10 4	8 225	
158	Σ 1143		7 41 41	5 42	.	.	7 0 11 0	8 063	No companion
159	Σ 1152	. .	7 44 58	− 2 49	314 1	6 05	8 2 . 9 9	8 225	
160	Σ 1154		7 46 7	− 2 45	352 9	2 41	7 7 9 9	8 225	
161	β 101	9 Argûs . .	7 46 12	−13 35	305 3	1 19	5 2 6 5	8 170	Doubtful distance
					298 8	.		8 214	Too poor for distance.
					303 6	0 41	.	8 227	Good
162	OΣ 183 *rej*	.	7 47 8	16 21	19 8	16 46	7 11	8 057	Difficult, and not well seen
					18 9	15 67		8 088	
					20 7	16 43		8 225	B = 12–13 m.
163	Σ 1171	Cancri 5 .	7 53 51	23 55	333 8	2 93	6 2 10 7	8 063	
164	Σ 1175	.	7 56 6	4 29	222 5	1 81	7 8 9 7	8 088	
165	Σ 1213 .	..	8 11 32	6 50	325 1	7 43	9 0 11 5	8 225	
166	Σ 1216	.	8 15 15	− 1 13	158 4	0 47	7 5 8 2	8 068	
					156 3	0 65	.	8 091	
					159 6	0 84	.	8 219	Distance too large
					160 8	0 50	.	8 227	First rate measure

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
167	OΣ 193	L 16548	8 20 34	33 56	298 1	14 17	7 2	12 0	8 041	
168	Σ 1230		8 21 37	17 15	192 7	29 90	8 3	10 0	8 219	
169	Σ 1233	P VIII 81	8 22 26	− 2 7	330 3	18 15	7 2	11 5	8 099	No change
170	Σ 3119	W^1 viii 638	8 26 7	8 54	215 9	26 21	8 0	11 0	8 225	= Σ 3066 *rej*
171	H 457	δ Cancri	8 37 54	18 36	113 9	41 08	5	15	8 239	
172	Σ 1273	ε Hydræ	8 40 25	6 52	223 1	3 46	3 8	7 8	8 225	A and B
					192 2	20 50			7 994	A and C
173	Σ 1281		8 41 26	0 28	321 3	31 18	7 8	8 9	8 091	
174	A G C 3	ρ Hydræ	8 42 5	6 17	145 9	12 16	5	12–13	7 994	
					143 9	12 84			8 057	
					144 9	12 19			8 170	
175	β 24	L 17586	8 48 24	− 8 18	177 3	1 12	7 8	9 0	8 186	
176	Σ 1327	L 18224	9 8 26	28 25	77 8	13 47	8 0	9 2	8 131	A and B
177	Σ 1329		9 9 37	− 0 44	248 4	22 84	8 3	8 5	8 131	
178	Σ 3121	W^2 ix 176	9 10 46	29 5	185 2	0 36	7 5	7 8	8 211	
179	Σ 1356	ω Leonis	9 22 2	9 35	68 0	0 73	6 2	7 0	8 068	
					72 6	0 53			8 153	
180	ℌ IV 47	3 Leonis	9 22 6	8 43	78 7	25 33	6½	13	8 186	Mags from Sm
181	OΣ 207 *rej*	L 19259	9 43 17	17 24	323 2	19 24	7 7	11 2	8 285	
182	Σ 1385		9 43 23	17 7	356 9		8 5	10 7	8 186	Too poor for distance
					350 5	1 14			8 211	
183	A C 5	8 Sextantis	9 46 34	− 7 32	150 0	0 2 ±	5½	5¾	8 208	Slight elongation with 900
					172 0				8 323	Less than 0″ 25
184	Anderson	A, 31 Leonis	10 1 32	10 35	42 6	8 25	5	13–14	8 153	
					45 8	7 01			8 323	Only seen with low power
185	Winlock	α Leonis (Regulus)	10 2 0	12 33	90 8	3 21	8 4	13	8 041	B and C
					84 9	3 47			8 063	
					88 6	3 27			8 153	
					89 8	3 23			8 323	
186	Σ 1416		10 6 29	−15 30	276 7	11 84	6 7	8 5	8 285	
187	OΣ 215	P X 23	10 9 44	18 20	225 4	0 65	6 5	7 3	8 068	
188	OΣ 523	39 Leonis	10 10 39	23 43	297 9	7 05	5 8	11 5	8 041	
					299 5	6 29			8 249	
189	Σ 1423		10 12 37	21 10	69 7	1 28	8 6	9 3	8 211	
190	*H* 4311	L 20158	10 17 26	−12 46	124 3	3 88	7	14	8 416	
191	Σ 1445		10 26 35	− 0 15	160 0	2 71	8 8	11 8	8 285	
192	H 165	W^1 x 499	10 29 46	12 14	205 3	2 59	8	9	8 285	Mags 8 5 8 5
193	OΣ 226 *rej*	L 20595	10 33 47	42 9	58 4	17 89	7	10	8 151	
194	H 838	41 Sextantis	10 44 17	− 8 16	303 8	26 95	6	17–18	8 186	Not measured by H
195	De 14		10 45 51	− 6 33	193 1	5 86	8 0	11 2	8 131	A and B
					195 1	6 19			8 417	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
196	OΣ 230	L 20971	10 48 4	21 35	13 4	8 36	8 0	12 0	8 239	
197	Σ 1524	ν Ursæ Majoris	11 12 0	33 45	146 0	7 07	3 7	10 1	8 260	No change
198	Σ 1543	57 Ursæ Majoris	11 22 37	40 0	7 1	5 43	5 2	8 2	8 425	
199	OΣ 234	L 21874	11 24 20	41 57	187 1	0 35	7	7–8	8 246	Distance too large
					151 7	0 27			8 323	Very good
200	Σ 3072	P XI 91	11 24 44	− 6 3	330 0	9 53	7 4	10 4	8 244	Unchanged
201	H 1201	B A C 4005	11 44 48	12 54	190 0	14 75	6–7	13	8 244	H 189° 0 12″ ±
202	OΣ 243	R 2777	11 53 38	54 4	14 5	0 94	8 3	9 0	8 296	
203	Σ 1607		12 5 30	36 45	358 1	30 85	7 8	8 3	8 260	A and B }
					309 8	21 04			8 260	B and C }
204	H 203	W¹ xii 94	12 8 6	− 5 3	351 6	30 20	6	19	8 244	A and B } No other measure
					197 7			14	8 244	A and C } B = 12 m
205	OΣ 245	W² xii 199	12 11 28	29 36	278 1	7 83	6 2	10 5	8 291	
206	OΣ 246	R 2828	12 12 24	69 28			7–8		8 299	Certainly round
207	Σ 1630		12 13 3	57 2	171 5	2 59	8 3	9 0	8 299	
208	Σ 1632	Canes Ven 20	12 14 15	38 34	192 1	10 48	6 5	9 7	8 249	No change
					192 4	10 10			8 396	
209	OΣ 247 *rej*	W¹ xii 237	12 16 10	3 58			7		8 323	} Absolutely round with 925
210	OΣ 248 *rej*	L 23206	12 18 3	6 38			7		8 323	}
211	OΣ 249	R 2853	12 18 3	54 49	307 1	0 46	7 5	8 0	8 299	A and B }
					148 3	12 68		11 0	8 299	A and C }
212	OΣ 250	L. 23220	12 18 31	43 45	329 0	0 47	7 5	7 7	8 151	
213	Σ 1641		12 18 38	38 24	39 2	8 94	10 0	10 5	8 260	
					39 3	8 99	.		8·291	
214	Σ 1643		12 21 13	27 42	46 6	1 76	8 4	8 7	8 291	
215	Σ 1644		12 21 18	8 3	246 3	21 15	8 7	9 2	8 285	
					247 2	20 97			8 323	
216	Σ 1675		12 38 40	35 4	8 2	30 66	8 3	9 0	8 260	
217	OΣ 255 *rej*	W¹ xii 564	12 40 8	3 7	337 6	20 20	7	10	8 285	B = 12 m
218	Σ 1682	P XII 196	12 45 8	− 9 41	305 6	32 48	6 7	9 0	8·255	
					306 2	32 10	..		8 274	
					305 5	32 47			8 285	
219	H 522	30 Comæ	12 45 51	28 13	10 0	43 17	6	18	8 151	No other measures
220	Σ 1702		12 52 56	38 56	82 5	35 73	8 0	8 5	8 260	
221	Σ 1703	L 24179	12 53 7	8 33	281 1	18 86	8 0	11 0	8 274	
					282 6	18 59			8 359	
					280 8	18 92			8 244	
222	A G C. 6	46 Virginis	12 54 25	− 2 43	154 3	1 46	6 0	11 0	8 323	A and B }
					148 7	1·51			8 359	}
					116 9	33 86		13	8 277	A and C }
223	Σ 1705 ...		12 54 49	15 2	188 0	26 84	8 2	9 7	8 353	No change

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° '	°	"				
224	Σ 1707	...	12 55 17	16 31	35 2	9 70	8 5	10 3	8 274	
					35 8	9 99			8 285	
225	Σ 1711		12 56 54	14 7	349 7	1 06	8 5	9 0	8 285	
226	H 2638	P XII 268	13 0 27	29 40	218 9	6 54	6	14	8 422	A and B }
					7 2	40 28		15	8 422	A and C } C faint
227	Σ 1727		13 4 12	32 1	337 8	7 70	8 7	10 2	8 291	
					335 4	7 56			8 422	
228	H 2645	53 Virginis	13 5 40	−15 33	9 3	70 80			8 236	B = 12–13
229	H VI 90	61 Virginis	13 12 10	−17 38	25 7		4½	10½	8 285	
					24 8	189 96			8 353	
230	Σ 1737	P XIII 63	13 15 58	18 24	220 2	15 13	7 7	10 0	8 274	
231	β 460	W¹ xiii 273	13 18 40	−15 0	33 6	1 99	8 0	10 5	8 277	
232	OΣ 268 *rej*	L 25006 .	13 25 11	24 51	77 1	19 61	7	11 8	8 274	A and B }
					259 0	67 86		7	8 274	A and C }
233	H 2659	W² xiii 542	13 28 11	40 33			8–9	18	8 260	
234	H 3340		13 30 47	16 35	217 2	2 27	11	11	8 244	
235	H 3341	W² xiii 615	13 32 14	28 56	191 4	2 80	10 =	10	8 151	Mags 10 10 5
					196 2	2 56			8 274	
236	Σ 1771		13 33 32	70 23	75 8	1 97	7 8	8 5	8 299	
237	Σ 1775	B A C 4571	13 37 17	− 3 40	335 4	27 93	7 0	9 7	8 255	
					336 4	27 68			8 277	
238	Σ 3081 ..	W¹ xiii 645	13 38 46	−11 14	67 4	2 05	8 8	9 2	8 277	
					67 0	1 99			8 285	
239	OΣ 270	τ Bootis .	13 41 35	18 3	351 0	8 95	4 8	11 7	8 151	
					351 4	8 94			8 244	
					352 9	8 31			8 337	
					352 2	8 66			8 422	
240	Σ 1784		13 42 12	69 49	208 7	9 00	8 2	10 5	8 299	
241	OΣ 272	P XIII 242 .	13 49 1	30 30	20 9	1 41	7 2	9 7	8 291	
242	Σ 1791		13 51 1	15 1	159 7	21 12	8 7	9 5	8 274	
243	Σ 1801		13 59 42	6 32	66 9	19 38	9 0	10 5	8 277	
					68 1	19 37			8 348	
244	Σ 1803		14 1 24	38 59	42 6	17 87	7 7	9 5	8 260	Fixed
245	Σ 1805		14 3 55	4 35	34 5	4 70	8 4	8 5	8 277	
246	Σ 1809 -		14 4 14	46 42	194 8	4 09	8 5	11 7	8 291	
247	Σ 1820		14 9 5	55 53	67 4	2 32	8 2	8 5	8 299	
248	Σ 1827	O² Arg 14419	14 10 32	59 48	210 8	11 35	8 5	9 0	8 296	Fixed
249	Σ 1832		14 12 51	4 27	131 4	0 65	9 0	9 0	8 323	A and B }
					69 6	19 16		(14)	8 323	A and C }
250	Σ 3083	Arg (24°) 2719	14 14 12	24 4	230 7	4 48	8 3	11 0	8 337	
251	Σ 1843		14 20 15	48 23	187 7	20 02	7 2	8 7	8 260	

No	Double Star	Star Catalogue.	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
252	Σ 1847		14 22 14	− 9 40	258·0	22·68	8·5	9·8	8·274	
					257·6	22·58			8·348	
253	OΣ 283	R 3220	14 28 17	49 43	132·4	5·05	7·5	11·0	8·260	
					129·8	4·95			8·296	
254	OΣ 284	R 3245	14 36 6	49 13	103·5	7·23	7·3	11·0	8·260	
					101·3	7·11			8·296	
255	Σ 1870		14 37 1	8 35	230·5	4·56	7·8	10·7	8·285	
					231·0	4·45			8·348	
256	Σ 1874		14 38 1	49 38	288·6	26·32	7·7	9·2	8·260	
257	Σ 1879		14 40 23	10 10	217·1	0·42	7·8	8·8	8·438	
258	β 106	μ Libræ	14 42 44	−13 39	333·2	1·50	5·5	6·3	8·321	A and B
					229·2	27·35		12–13	8·321	A and C
259	H 5489	B A C 4902	14 44 48	29 7	23·0	112·56			8·337	
260	β 31	L 27106	14 46 59	19 13	187·8	1·29	8·5	10·2	8·246	A and B
					161·4	9·04		12–13	8·246	A and C
261	H 2752	Arg (45°) 2228	14 47 4	45 6	126·5	5·84	9	10	8·260	Mags 8 10·5
262	Sh 190	P XIV 212	14 50 27	−20 52	291·3	15·67	7	8	8·277	A and B
					290·4	15·05			8·323	
					291·8	15·40	.		8·348	
					289·5	15·20			8·509	
					171·0	52·5		.	8·323	A and C
					52·5	69·4	.	.	8·323	A and D
					166·5	105·5			8·323	A and E
					322·2	121·6	.		8·323	A and F
263	β 239	59 Hydræ	14 51 33	−27 10	129·5	0·93	6	6	8·362	
264	β 348	2 Serpentis	14 55 40	0 20	121·4	0·51	6	7·5	8·362	Very difficult.
265	Σ 1914		15 5 25	− 5 2	335·4	30·91	8·0	8·7	8·277	
					336·2	31·74			8·351	
266	Σ 3091		15 9 43	− 4 26	225·0	0·25±	7·7	7·7	8·362	
267	OΣ 294	L 27867	15 9 46	56 30	249·1		7·3	11·0	8·296	Clouded before distance
					248·3	2·75	.	.	8·299	
268	Σ 1926		15 10 23	38 45	254·8	1·46	6·1	8·4	8·422	Unsteady
					259·1	1·43			8·444	Good
269	OΣ 295	L 27853	15 10 24	37 16	128·7	0·75	8·0	9·3	8·411	
270	Σ 1925		15 10 28	− 7 50	10·2	4·91	7·8	9·3	8·438	
271	Σ 3093	L 28015	15 16 26	− 1 6	139·9	30·79	8·0	9·2	8·348	
272	Σ 1937	η Coronæ	15 18 14	30 43	90·8	0·62	5·2	5·7	8·411	
273	Σ 1938	μ² Bootis	15 20 0	37 46	136·2	0·68	6·7	7·3	8·411	
274		γ Libræ	15 28 48	−14 23	151·8	41·31	4½	11·7	8·323	
275	Σ 1959	W² xv 668	15 29 58	35 10	242·3	2·08	8·7	10·2	8·411	No change
276	Σ 1961	Arg (44°) 2483	15 30 29	43 56	44·6	22·45	8·7	9·0	8·291	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
277	OΣ 298	W² xv 716	15 31 42	40 13	128 7	0 23	7 0	7 4	8 249	Not quite separated
					132 8	0 31			8 411	Both good measures
278	Σ 1962	Libræ 178	15 32 11	− 8 24	187 8	11 99	6 3	6 4	8 487	Fixed
279	Σ 1964		15 33 41	36 38	10 0	1 34		8 8	8 381	B and C }
					88 1	15 52	6 8	7 3	8 381	A and B }
280	Σ 3095	W¹ xv 705	15 36 15	−14 48	337 8	2 72	8 3	9 8	8 452	
					337 9	2 95			8 455	
281	H 1277	α Serpentis	15 38 21	6 48	354 5	58 89	2	14–15	8 351	H 359° 5
282	A G C 8	ε Coronæ	15 52 37	27 14	357 3	1 94	4	12–13	8 246	
					3 1	1 78			8 473	
283	Σ 2001		15 57 10	42 10	168 8	11 93	8 7	10 5	8 291	
284	Σ 2006		15 58 1	59 16	196 8	1 66	7 5	9 2	8 425	
285	β 120	ν Scorpii	16 5 1	−19 9	0 8	0 8 ±	4 2	6 7	8 244	Too poor for distance
					7 2	1 08			8 383	Unsteady
					3 0	1 00			8 438	
286	Σ 2022		16 7 48	26 59	136 4	2 89	6 2	9 8	8 444	
287	Σ 2032	σ Coronæ	16 10 12	34 10	202 8		5 0	6 1	8 378	Clouded before distance
					201 8	3 51			8 400	The 16″ star not seen
288	Σ 2036		16 10 29	72 52	241 5	2 18	8 8	10 3	8 425	A and B }
					341 1	15 67		16	8 425	A and C }
289	Σ 2048	P XVI 88	16 22 20	− 7 52	301 3	5 04	6 3	9 0	8 493	Probably fixed
290	OΣ 312	Draconis	16 22 22	61 47	141 7	5 26	2 9	9 0	8 381	
291	Σ 3105	W¹ xvi 447	16 25 21	− 6 46	50 9	0 61	7 7	7 7	8 493	
292	Σ 2062		16 28 42	8 56	114 2	2 80	8 3	10 0	8 458	B = 11 m
293	Σ 2084	ζ Herculis	16 36 47	31 49	127 0	1 51	3 0	6 5	8 408	
294	Σ 2092		16 37 24	60 56	5 2	8 18	7 7	8 8	8 425	
295	Σ 2106		16 45 24	9 37	323 7	0 64	6 7	8 4	8 383	
296	Σ 3106	W¹ xvi 912	16 49 17	− 4 59	247 2	2 19	8 6	8 6	8 482	
					246 4				8 487	Haze, too faint for distance
297	OΣ 317	L 30818	16 49 18	44 36	228 1	17 30	7	11–12	8 299	
					228 9	17 29			8 337	
298	Σ 2110 *rej*	56 Herculis	16 50 6	25 56	93 4	18 13	6½	10	8 449	
299	Σ 3107	W¹ xvi 977	16 52 52	4 9	100 1	1 38	8 5	8 5	8 458	
300	OΣ 321	L 30918	16 53 55	14 29	2 6	0 55	8 0	8 0	8 458	
301	Σ 2117		16 55 14	51 59	116 3	1 29	8 4	10 6	8 299	Difficult to night
302	Σ 2115	Herculis 192	16 56 6	15 7	238 5	18 88	5 7	10 5	8 383	
303	Σ 2124		16 58 47	65 23	89 4	15 04	8 5	9 2	8 299	No change
304	♅ V 133	60 Herculis	16 59 49	12 54	309 7				8 438	Clouded
					309 8	53 38			8 515	
305	Σ 2122	Ophiuchi 124	17 0 39	− 1 30	279 6	20 34	6 5	8 7	8 482	Fixed
306	Σ 2140	α Herculis	17 9 10	14 32	117 5	4 99	3 0	6 1	8 458	A and B }
					38 7	85 39		12–13	8 458	A and C }

No	Double Star	Star Catalogue	R A 188 0	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
			h m s	° ′	°	″			
307	H 854	W¹ xvii 143	17 10 27	1 21	358 8	20 24	5 17	8 509	No other measures.
308	OΣ 327	R 3689	17 11 53	56 16				8 476	
309	OΣ 328	68 Herculis	17 12 54	33 14	62 4	3 88	5 1 10 1	8 395	No change
					60 6	4 22		8 411	Good
310	σ 544	72 Herculis	17 16 10	32 28			6	8 395	
311	Σ 2163		17 19 36	42 16	97 2	1 58	9 2 9 2	8 299	
312	Σ 2172		17 23 44	− 1 15	170 5	11 62	8 0 10 8	8 509	
313	Σ 2175		17 25 0	32 48	10 1	13 30	8 0 10 0	8 395	No change
314	Σ 2178		17 25 11	35 2			7 0 8 6	8 449	
315	Σ 2190	P XVII 163	17 30 52	21 4	23 9	10 16	6 0 9 5	8 493	
316	OΣ 333		17 31 13	10 39			7	8 622	Single
317	Do 16	Arg (43°) 2795	17 39 45	43 48	147 9	0 97	9 5 11 0	8 299	B and C
					212 7	19 45	8 5	8 299	A and BC
318	Σ 2205		17 40 ±	17 46	305 1	2 30	8 3 8 7	8 622	
319	A C 7	μ Herculis	17 41 47	27 48	233 1	1 04		8 337	B and C
					237 8	0 92		8 411	
					229 5	1 16		8 444	Unsteady
					235 7	1 02		8 473	Seeing perfect
					234 6	1 22		8 529	
					238 9	0 95		8 610	Good
					243 4	30 54		8 444	A and BC
320	Σ 2215	W² xvii 1314	17 41 49	17 44	301 1	0 71	5 9 · 7 9	8 622	
321	Σ 2237		17 46 14	41 59	7 4	20 28	7 2 · 9 5	8 299	No change
322	Σ 3128	W¹ xvii 905	17 46 28	− 7 53	35 0	1 25	7 2 11 0	8 323	
323	OΣ 338	L 32693	17 46 33	15 21	202 9	0 75	6 4 7 7	8 636	
324	II 4995	L 32695	17 47 26	−11 19			6½	8 512	
325	β 283	B A C 6088	17 54 38	−22 47	238 3	8 20	6 12–13	8 504	No other measures
					240 1	8 26		8 507	
326	𝔥 N 40	L 32971	17 55 6	−23 1	21 4	5 98		8 501	A and B
					22 6	5 73		8 504	
					212 4	10 85		8 501	A and C
					282 5	2 18		8 501	C and D
					280 2	2 26		8 504	
					182 5	6 10		8 512	C and E
					214 5	29 71		8 512	C and G
					82 1	28 37		8 512	C and F.
327	Σ 2272	70 Ophiuchi	17 59 23	2 33				8 625	Both stars round
328	II 5493	72 Ophiuchi	18 1 42	9 33	167 6	51 70	4 14	8 622	
329	A C 15	99 Herculis	18 2 28	30 33	26 6	1 09	6 0 10 5	8 458	
					20 6	0 90	11 0	8 460	
					26 1	0 97		8 473	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
			h m s	° ′	°	″			
330	A G C	102 Herculis	18 3 38	20 48	46 9	23 42	5½ 12–13	8 449	
331	H 2822	*μ* Sagittarii	18 6 35	−21 5	259 2	16 91	3–4 14	8 422	A and B
					117 4			8 422	A and C
					118 7	25 20		8 512	
332	*β* 286	16 Sagittarii	18 8 9	−20 25	219 6	5 49	6 13	8 490	
					218 3	5 74		8 504	
					217 7	5 78		8 701	
333	H 2827		18 9 59	−19 55	253 6	19 67	9–10=9–10	8 422	
334	*β*——	R 3883	18 12 35	56 33	186 1	5 99	11 0 11 0	8 425	B and C
					239 3	95 96	7 0	8 425	A and B
335	H 5495	74 Ophiuchi	18 14 53	3 19	285 6	27 96	5 15	8 512	No other measures
336	Σ 2315	Herculis 452	18 20 12	27 20	251 7	0 31	7 0 8 0	8 449	
337	Σ 2318		18 20 37	25 56	254 9	20 81	8 0 10 2	8 441	
338	OΣ 351	R 3923	18 22 11	48 42	29 7	0 63	7 1 7 4	8 408	
339	Σ 2327	Arg (29°) 3270	18 24 33	29 51	310 0	19 01	7 3 11 0	8 441	B = 11 m
340	OΣ 355 *rej*	L 34350	18 27 38	8 11			6 2	8 636	Round
341	Σ 2344	Arg (28°) 3027	18 30 19	28 38	180 4	1 58	8 5 12 0	8 441	
342	OΣ 357	Arg (11°) 3518	18 30 21	11 37	258 9	0 52	7–8 7–8	8 636	
343	Σ 9 App II	*a* Lyræ (Vega)	18 32 52	38 40	154 9	48 01	1 0 10 5	8 408	A and B
					154 9	48 11		8 534	
					289 9	51 66	13–14	8 337	A and C
					292 9	51 97		8 395	
					293 1	51 93		8 408	
344	Σ 2358		18 34 0	30 37	218 5	2 90	8 8 9 0	8 529	
345	Σ 2384	L 34968	18 38 33	67 0			8 0 8 5	8 476	Single
346	Sh 277		18 40 23	39 31	38 4	46 61		8 337	A and B
					38 5	46 81		8 381	
					357 4	24 94		8 337	C and D
					354 7	25 09		8 389	
					247 3	42 57		8 337	A and C
347	*β* 293	*β* Lyræ	18 45 39	33 13	247 2	46 35	3 13	8 337	A and C
					248 8	46 26		8 389	
					149 1	45 64	6 7	8 389	A and B
348	OΣ 364	L 35242	18 48 24	25 14			7–8 11	8 411	
349	OΣ 525	Lyræ 91	18 50 28	33 49	124 6	1 56	5 5 9 5	8 408	A and B
350	OΣ 365	L 35438	18 52 20	44 4				8 408	
351	OΣ 544	*γ* Lyræ	18 54 27	32 31	300 8	12 80	3 2 12 0	8 408	
					301 5	12 72		8 460	
352	Winlock	*ζ* Sagittarii	18 55 0	−30 3	84 2	0 42	3½ 4	8 701	
353	Σ 2434	P XVIII 274	18 56 34	− 0 53	64 1	1 53	8 4 10 3	8 636	B and C
354	*β* 287	*ζ* Aquilæ	18 59 54	13 41	61 0	4 90	3 12	8 458	Rather difficult

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
					58·0	4·98			8·512	Windy
					59·9	4·88			8·636	
355	Σ 2462	.	19 3 30	3 12	156·2	8·79	9·5	9·5	8·698	A and B
					231·6	8·62		12·5	8·698	A and C
					71·8	5·95		12·5	8·698	B and D
356	Σ 2464		19 3 36	11 41	22·2	1·15	8·2	10·5	8·636	But little change
					25·2	1·24			8·689	
357	II 879	21 Aquilæ	19 7 39	2 5	286·4	36·19	6	19	8·449	No measure in H
358	OΣ 368	W° xix 279	19 10 37	15 57	220·4	0·93	7·1	8·4	8·636	A and B
					212·9	1·18			8·689	Very unsteady
					215·4	0·99			8·706	
					98·2	17·37			8·636	A and C
359	Σ 2508		19 14 24	67 39	117·8	17·99	8·7	9·0	8·425	Σ 117°·7 17″·65 (1832·4)
360	Σ 2514		19 16 49	67 28	316·7	8·49	9·0	11·3	8·397	
					316·0	8·53			8·425	
361	Σ 2512		19 18 5	31 30	310·5	22·33	7·5	9·8	8·471	
362	Σ 2515		19 19 23	21 17	24·3	13·08	8·0	9·0	8·597	
					23·3	12·89			8·703	
363	Σ 2536		19 26 16	17 32	64·5	1·76	8·0	11·0	8·698	
364	Σ 2538		19 27 3	36 27	52·8	5·97	8·3	8·7	8·471	B and C
					238·5	21·09		13	8·471	A and *c*
365	Σ 2544		19 31 19	8 3	238·8	15·63	7·8	8·5	8·616	Too poor for AB.
366	II 599	54 Sagittarii	19 33 52	−16 33	244·5	35·76	5–6	14	8·698	A and B. Mags.
					41·7	45·57		10	8·698	A and C 5 11·5 9
367	Σ 2557		19 34 49	29 28	103·4	10·76	7·3	9·8	8·473	A and B
					303·4	20·95		11·0	8·473	A and C
368	Σ 2564		19 35 49	63 33	175·1	10·04	8·5	10·2	8·397	
369	OΣ 380	χ Aquilæ	19 36 55	11 33	82·9		5·7	7·7	7·681	
					76·6	0·55			7·684	
					68·2	0·93			7·725	
					72·9	.			7·728	
					72·5	0·44			7·775	
370	OΣ 382	L 37472	19 37 0	27 6	175·3	0·45	7·0 ...	7·0	8·529	
371	Σ 2574	. ..	19 39 5	62 23	145·0	0·63	8·0	8·0	8·476	
372	A G C 11	P XIX. 257 ..	19 39 15	10 29	126·1		7·5 .	7·5	7·681	A and B
					147·4				7·725	
					147·0	0·26			8·622	
					142·0	0·32		.	8·701	
					279·3				7·681	AB and C
					276·6	4·16		9·5	8·703	
373	OΣ (App.) 190	L 37628 .	19 39 50	46 57	300·2	11·64	7·5	12–13	8·397	A and B
					316·8	67·32		9·0	8·397	A and C

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
374		γ Aquilæ	19 40 33	10 19	267 8	50 2	3	11 0	7 666	A and B
					30 4				7 666	A and C
					257 6				7 66	A and D
375	Σ 2579	δ Cygni	19 41 13	44 50	333 7	1 40	3 0	7 9	8 647	
					332 6	1 40			8 649	
376	A G C 12	ζ Sagittæ	19 43 39	18 51	158 3	0 22	6	6	7 722	A and B
					157 6	0 24			7 728	
					158 1	0 27			7 775	
					158 7	0 35			8 636	
					155 4	0 35			8 701	
377	H 2904	B A C 6814	19 47 8	−24 14	140 8	18 39	6	10	8 706	Mags 7 10
378	OΣ 532	β Aquilæ	19 49 25	6 7	18 2	12 01	3 4	11 3	8 597	
					15 2	11 96			8 622	
					16 1	12 03			8 625	
379	β 425	L 38087	19 52 15	19 58	240 2	1 32	8 8	9 0	8 625	A and B
					39 3	19 61		12 0	8 625	A and C
380	A C 16		19 52 57	26 56	237 7	0 45	7½	8	8 678	A and B
381	OΣ 392	Cygni 116	19 53 54	41 56	317 0	0 31	7 0	9 0	8 534	A and B
					289 2	3 32		9 0	8 534	AB and C
382	H IV 100	χ Sagittæ	19 54 38	17 11	205 4	28 96		12	8 698	
383	Σ 2612		19 55 31	6 36	53 3	38 03	7 8	8 8	8 458	
384	β 439		19 55 56	29 30	159 9	1 52	8 0	12 0	8 411	
385	Σ 2615	L 38279	19 57 5	8 4	319 6	10 51	7 2	10 1	8 458	
					317 2	10 68			8 625	
386	Σ 2619		19 57 29	47 56	242 2	4 42	8 1	8 1	8 397	A and B
					294 2	18 40	11–12		8 397	A and C
387	H V 147	26 Cygni	19 57 58	49 46	146 8	41 76	5 5	8 5	8 408	A and B
					73 7	8 99		11 0	8 408	B and C
388	β 57	L 38415	19 59 55	15 9	123 4	2 50	6 2	10 6	7 703	Mags by De
389	β 429, 440	L 38520	20 1 27	35 27	61 1	6 63	7	12–13	8 534	A and B
					25 1	8 39		12	8 534	A and C
390	Σ 2635	Aquilæ 231	20 4 19	8 6	79 3	7 18	7 0	10 5	8 706	No change
391	OΣ 400	L 38758	20 6 14	43 35			7 3	7 7	8 647	Single with all powers
392	Σ 2652		20 7 3	61 43	269 9	0 42	7 3	7 6	8 534	Well separated
393	Σ 50 App I	o^2 Cygni	20 9 51	46 23	173 8	106 63	3 7	6 5	8 389	A and B
					321 7	36 82		17	8 389	A and *a*
					169 6	43 19			8 389	A and *b* Last three single distances
					91 7	40 1			8 389	B and *c*
					61 8	60 5			8 389	B and *d*
					136 0	60 5			8 389	B and *e*
394	Σ 2658		20 10 29	52 45	119 9	5 21	7 0	9 1	8 649	A and B
					212 4	40 50		10 2	8 649	A and C

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags	Epoch 1870+	Notes
			h m s	° ′	°	″			
395	A G C 13	α^2 Capricorni	20 11 24	−12 55	150 3	7 77		8 512	A and BC
					151 4	7 07		8 534	
					148 8	7 39		8 589	
					62 6	1 23	12 12	8 512	B and C
					59 8	0 89		8 534	
396	Σ 2662		20 12 50	10 37	36 6	1 65	8 2 11 0	8 537	
397		ν Capricorni	20 14 0	−13 8	210 1	55 38		7 775	12–13 m
398	H N 138	O¹ Arg 20475	20 17 42	−17 23	330 6	2 93		8 722	Mags 8 0 8 5
399	β 443	L 39293	20 19 12	28 37	134 3	12 98	7 5 11 5	8 473	A and B } Another star
					87 4	35 22	12	8 473	A and C } 25″ *sf*
400	β 363	Vulpeculæ 93	20 24 28	20 12	62 8	21 77	7 . 12	8 706	
401	β 63	1 Delphini	20 24 33	10 30	345 0	1 22	6 8	8 458	Unsteady C not seen Distance too large
402	Σ 2690	P XX 178	20 25 29	10 51	108 5	23 65	7 16	7 807	A and D
					108 4	23 16		8 722	
403	Ma 8	W¹ xx 688	20 28 15	11 41	248 1	19 29	8 5 11 0	7 807	
					248 7	18 98		8 722	
404	Σ 2703		20 31 13	14 19	290 3	24 96	7 6 7 6	8 722	A and B
					217 1	57 78	7 6	8 722	B and C
					238 1			8 722	A and C
405	β 151	β Delphini	20 31 55	14 11	45 6	0 38		7 760	A and B.
					35 0		...	7 775	
					41 2	0 26	.	7 818	
					41 3	. .		7 829	Est. 0″·25.
					52 3	0 22	.	8 622	
					52 2	0 28	. .	8 633	
					52 1	0 20	. .	8 636	
					58 4	0 27		8 701	
					117 2	27 74		7 701	A and C
					115 7	27 86		7 821	
					115 7	27 37		8 625	
					335 6	35 06	.	7 701	A and D
406	OΣ 533	κ Delphini	20 33 17	9 40	329 8	10 70	4 8 .11 4	7 725	
					329 1	10 43		7 807	
					329 3	10 43		8 468	
					328 5	10 82		8 722	
407	II. 1554	α Delphini	20 34 3	15 29	279 7	42 02	5–6 13	7 821	A and C.
					279 9	42 47		8 722	
					330 2	47 96	13	7 821	A and D.
					114 1			7 821	A and E.
408	β 288	Delphini 32	20 34 31	15 25	167 8	7·87	7 13–14	8 537	Difficult.

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
409	Σ 2714		20 35 17	29 20	341 9	6 87	8 5	12 0	8 436	Not good
410	β 267		20 35 25	− 4 50	151 9	2 11	9·0	9 0	8 678	No other measures
411	Σ 2720		20 37 56	16 31	182 1	4 07	8 5	8 7	8 698	
412	Σ 2723	Delphini 43	20 39 11	11 53	33 6	38 7	6 4	12	7 701	A and C
413	β 152	Cephei 55	20 39 18	56 57	112 3	0 55	7 0	9 0	8 534	
414	OΣ 413	λ Cygni	20 42 44	36 3	85 3	0 74	5 5	7 6	8 529	
415	Σ 2734		20 48 21	12 39	191 3	25 66	8 2	8 7	8 537	
					191 0	25 81			8 597	
					191 4	26 00			8 698	
416	OΣ 418	L 40485	20 49 54	32 15	294 8	1 2 ±	7 3	7 3	7 769	
417	OΣ 419	W² xx 1574	20 50 1	36 37	38 0	1 65	7 3	10 3	7 758	
418	OΣ 424	L 40628	20 53 39	15 6	327 6	0 45	7–8	8–9	8 594	A and B
					327 9	0 45			8 678	
					306 3				8 594	A and C
419	H 3006		20 54 52	2 28	112 1	1 94	10	10	7 818	
					110 0	1 69	10	19	8 537	
420	H IV 113	B A C 7313	20 57 45	39 2	299 9	18 72	6	10	8 471	A and B
					250 0	25 80		12	8 471	A and C
421	Σ 2749		20 58 43	3 3	147 3	0 99	9 5	9 5	7 766	B and C
					150 5	1 26			7 818	
422	Σ 2752	Aquarii 43	21 0 29	−14 24	151 9	5 60	6 7	10 7	8 589	A and B
					83 7	20 99		12	8 589	A and C AC = β 157
423	527	W¹ xx 1550	21 2 1	4 40	279 4	0 64	7 2	7 2	7 760	The *p* star ½ mag smallest
					285 6	0 44			8 636	
					290 1	0 49			8 678	Mags 7 7 8 3
424	Star and Neb		21 2 14	47 22	243 1	26 63			8 468	* and neb
					245 0	28 05			8 476	
					88 5	2 57			8 476	Distance of nuclei
425	OΣ 429 *rej*	L 41005	21 3 22	4 33					8 678	Certainly single
426	Σ 2763		21 3 52	16 51	295 4	17 60	8 5	9 7	8 395	
					292 8	17 30			8 625	
427	Kn 2	γ Equulei	21 4 30	9 39	274 5	2 16	4 2	11 0	7 728	A and B
					10 0	41 34		12	7 728	A and C
428	β 270	Equulei 19	21 7 31	6 43	347 4	1 26	7	9	7 725	A and B A faint star at 32° 4
					172 6	183 40		7	7 725	A and C AC = S 781.
429	OΣ 535	δ Equulei	21 8 38	9 31	156 4	0 2 ±	4 5	5 0	7 760	Slight elongation
									8 633	No certain elongation
									8 678	Perhaps elongated in 180°, but doubtful
430	A G C 13	τ Cygni	21 10 0	37 32	150 0	1 06	4 9	7 4	8 408	Mags by De
431	OΣ 433	υ Cygni	21 12 58	34 23	218 5	14 77	4 5	10 3	8 436	A and B
					177 9	21 38		10 2	8 436	A and C

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
432	β 289	W² xxi 289	21 13 22	34 25	137·8	0·90	8·2	10·0	8·529	A and B
					262·1	5·39		13	8·529	A and C
433	OΣ 435	L 41486	21 15 19	2 23	205·9	0·62	7·5	7·8	8·678	
434	H 3023	β Equulei	21 16 56	6 18	260·1	32·09	5	13–14	7·776	A and B
					259·3	31·07			8·633	
					308·7	67·4			7·776	A and C Single distances
					10·4	6·03	14	15	7·728	C and D
					275·9	86·28	15		8·633	A and E,
435	H 5517	18 Aquarii	21 17 37	−13 23	325·7	47·84	6		7·824	Very faint
436	β 447	Vulpeculæ 129	21 18 45	24 48	329·7	8·59	6·5	13	7·802	No other measures
					331·1	8·45	6	12–13	8·625	
437	β 164	L 41645	21 19 13	8 52	237·3	0·82	8	8½	7·725	(AC = Σ 2793)
438	β 72	W¹ xxi 511	21 23 43	− 5 55	42·8	1·89	9	11	7·722	In the field with β 684
					43·4	1·90			8·622	
439	H 936	β Aquarii	21 25 14	− 6 6	320·0	34·26	3	15	7·701	AB
					185·6	55·04		12	7·701	AC.
440	β 273	W¹ xxi 646	21 28 33	10 55	93·3	5·63	8	12	7·821	
441	H 3040	ε Capricorni	21 30 22	−20 0	46·8	67·94	5	9	7·824	Faint star, 156° 70″
442	H 941	4 Pegasi	21 32 31	5 14	344·9	25·95	6–7	17	8·706	No measures by H
443	Σ 2822	μ Cygni	21 38 46	28 12	115·3	3·92	4	5	8·408	A and B
					117·2	3·84	..	.	8·436	
					262·7	35·40		12	7·717	A and C.
					263·0	35·16	.		8·408	
					56·3	208·52		7	8·436	A and D
444	H. 1691	L 42489	21 42 15	− 6 48	276·8	14·68	9	13	7·807	A about 8 m
445	H 947	P XXI 312	21 45 57	19 16	92·7	20·71	7	·15	8·395	H 275°·5 10″ ±. A and B
					324·0	24·40		17	8·395	A and C
446	Σ 2833		21 46 2	8 31	339·2	9·27	7·2	10·0	8·689	
447	Σ 2845		21 48 59	62 32	173·2	1·86	8·2	8·3	8·425	
448	H 3069		21 50 31	6 40	78·8	24·98	8	12	7·802	AB and C
449	OΣ 537	O² Arg 23107	21 52 10	59 16	202·5	2·21	8	10–11	8·649	
					200·6	2·12			8·657	
450	OΣ 458	R 5483	21 52 40	59 13	349·8	1·00	6·0 .	8·3	8·649	A and B
					354·1	0·72	.		8·660	
					32·9	22·71		12·5	8·649	A and C
451	Howe	L 42909 .	21 55 0	−16 11	270·5	8·94	6½	·11	8·633	A and B
					292·3			9	8·633	A and C.
452	H 289	20 Pegasi	21 55 14	12 33	326·1	51·28	5-6	12	7·780	(= H 5525)
453	S 802	29 Aquarii	21 55 51	−17 33	242·4	4·10	8	8½	7·701	
454	Σ 2860		21 59 26	60 16	256·1	6·13	7·7 . .	9·3	8·425	
					255·2	5·80			8·668	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870+	Notes
			h m s	° ′	°	″				
455	OΣ 460	Lam 8679	21 59 32	1 12	46 3	16 04		11 5	7 802	A and C
					351 8	6 71	7 5	12 0	7 802	A and B
456	β 474	0^2 Arg ¯23373	22 1 2	60 25	345 6	16 28	8	12	8 668	
457	OΣ 462	L 43165	22 1 48	35 31	31 0	6 95	7 5	9 5	7 780	A and C
458		π^1 Pegasi	22 3 54	32 35	284 4	27 40	5	12	7 780	A and B
					261 7	72 62		10	7 780	A and C
459	Σ 2869	Pegasi 129	22 4 32	14 2	253 1	21 23	5 8	11 8	7 780	
					253 6	21 53			8 698	
					253 4	21 82			8 722	
460	Σ 2879		22 7 18	62 48	228 3	0 91	8 0	8 0	8 660	
461	Σ 2877	P XXII 33	22 8 33	16 36	351 9	10 51	6 4	9 6	8 622	Proper motion
462	β 378	0^2 Arg 23808	22 12 50	60 16	90 4	3 33	8 2	8 5	8 649	A and B
					29 4	7 48		11 8	8 649	A and C
463	H 962	30 Pegasi	22 14 25	5 11	18 6	6 22	5	20	8 594	A and B
					223 0	10 04		19	8 594	A and C
464	H 3106	γ Aquarii	22 15 27	− 1 59	129 6	43 87	4–5	13	8 722	
465	β 172	51 Aquarii	22 17 52	− 5 27	25 4	0 59	6 5	6 5	7 695	
					24 9	0 35			7 829	
					25 5	0 56			8 612	
					23 8	0 84			8 636	Distance too large
466	β 290	34 Pegasi	22 20 30	3 47	214 4	2 62	6	13	7 695	
					220 0	2 56			7 717	
					221 0	2 41			7 818	
					219 0	2 89			8 636	
467	β 291	W^1 xxii 436	22 21 39	3 55	160 0	0 42	8 5	8 8	8 636	
468	β 478	Lam 4578	22 23 8	− 7 56	32 6	1 26	9	11	7 802	A and B
					32 7	1 38			8 594	
					239 0	28 55		9	7 802	A and C
469	OΣ 471 *rej*	Arg (6°) 5027	22 23 14	7 0			7		8 636	Single
470	Σ 2912	37 Pegasi	22 23 54	3 49	130 0	0'32	5 8	7 2	8 636	Very difficult
471	Σ 2915	W^1 xxii 527	22 26 33	6 48	155 6	12 40	8 5	8 7	7 804	
					154 6	12 18			7 829	
472	H 3128	L 44290	22 33 34	−19 49	226 2	10 70	8	12	7 701	No change in P
473	Σ 2936	Aquarii 215	22 36 50	0 35	50 8	4 92	7 0	10 0	7 829	
474	β 176	Arg (38°) 4848	22 37 5	38 40	42 0	2 50	8 7	9 0	7 785	Distance too large
475	OΣ 477	L 44497	22 38 13	45 24	154 1	4 62	7 0	11 2	8 641	Unsteady
476	Σ 2942	B A C 7931	22 38 40	38 50	279 4	2 64	7 0	9 2	8 473	A and B
					231 9	10 92		12	7 785	A and C
					233 0	10 95			8 473	AC = β 450
477	H 301	ξ Pegasi	22 40 42	11 33	112 0	11 99	5	18	8 622	
					111 4	11 87			8 625	

No	Double Star	Star Catalogue	R A 1880	Decl 1880	Position Angle	Distance	Mags		Epoch 1870 +	Notes
			h m s	° ′	°	″				
478	Σ 2944	P XXII 219	22 41 40	− 4 51	252 8	3 88	7 0	7 5	7 873	A and B
					140 8	48 65		8 2	7 873	A and C
479	H 3152	L 44810	22 48 40	−10 1			9	15	8 633	
480	Σ 2954		22 48 51	14 33	27 4	37 97	9 0	9 0	7 804	
481	β 383	L 44855	22 49 57	8 49	119 6	2 67	8	11	7 818	A and B
					240 5	15 25		11	7 804	A and C
					240 1	15 93			7 818	
482	Σ 2959	L 44872	22 50 55	− 3 53	102 2	13 65	6 5	10 5	7 804	A and B
					102 2	13 90			7 947	
					95 9	8 31		12–13	7 947	B and C
483	OΣ 536	B A C 8001	22 52 29	8 43	161 5	0 47	7	7–8	7 760	
484	β 481	W^1 xxii 1162	22 56 23	−11 53	53 0	1 31	9 0	9 5	7 760	Near Σ 2970
					50 7	1 29			8 622	
485	Σ 2976		23 1 38	5 57	263 7	8 00	8 3	10 2	7 804	A and B
					263 0	7 77			8 625	
					188 7	16 74		8 8	7 804	A and C
					187 9	16 59			8 625	
486	Σ 2980		23 2 58	− 7 58	111 8	4 38	7 2	10 2	7 758	
487	Σ 2982	57 Pegasi.	23 3 28	8 2	199 2	32 48	5 9	10 5	7 780	No change
488	OΣ 489	π Cephei	23 4 5	74 44	23 8	1 28	4 4 .	7 5	8 660	Binary
489	Σ 2987		23 4 49	48 22	164 4	3 68	7 3	10 2	8 471	Fixed.
490	β 181	Aquarii 286	23 7 31	−14 3	234 9	18 78	7 .	12	7 736	A and C
491	Σ 12 App II	ψ^1 Aquarii	23 9 35	− 9 44	34 9	18 4		.	7 695	B and
					275 0	63 0			7 695	A and D
492	β 80 .	L 40638 . ..	23 12 42	4 45	305 1	1 40	8–9.	11	7 766	
					307 1	1 09		.	7 818	
493	H 5394 ..	96 Aquarii	23 13 10	− 5 47	23 1	10 08	6 .	14	8 622	
494	S 830	κ Piscium	23 20 46	0 36	344 7	156 22	5	12	7 780	A minute star between
495	H 316	Aquarii 355	23 31 27	−13 44	92 7	33 22	7 .	11	7 829	H 91° 9·30″±
496	A G C 14	78 Pegasi	23 37 57	28 42	190 8	1 54	5 0	8 1	8 769	Mags. by Do
					192 8	1 69		.	8 775	
497	Σ 3036 .	P. XXIII 179 ..	23 39 52	− 0 24	227 9	2 38	7 8	10 8	7 859	Fixed
498	OΣ 506 *rej* ..	L 46645	23 42 32	35 37	79 4	18 09	7 0	10 3	7 802	
499	OΣ 509	L 46703 .	23 44 30	42 45	106 6	5 55	7 8 . .	9 2	7 785	Fixed
500	Σ 3046		23 50 15	−10 10	244 8	3 05	8 0 .	8 5	7 942	Slow motion
501	β 281	L 47148	23 56 38	1 28	214 0	1 19	7 5	11	7 717	A and B
					220 1	1 05			7 942	
					335 7	30 37		11	7 717	A and C
					336 0	30 51	.	.	7 942	
502	Σ 3055	... .	23 57 51	11 29	359 6	5 79	7 0 .	11 2	8 625	

Notes to the Micrometrical Measures

No 1. Σ 3063

The following are all the measures of this pair —

	°	″	
Σ	P = 232 9	D = 1 78	1831 5
De	223 7	1 85	1864 8
β	223 3	1 82	1877 9

No 2 H 1939

The only earlier observation is by H :—

	°	″
H	P = 158 3	D = 30±

There would seem to be no change in the direction. HERSCHEL'S declination is 5′ in error.

No 3

From an unpublished list of double stars from Professor PICKERING, Director of Harvard College Observatory. There are no other measures.

No 4 Σ 14

There is but little, if any, change in this pair :—

	°	″	
Σ	P = 235 6	D = 15 19	1830 9
De	236 4	14 27	1864 8
β	236 3	14 38	1877 9

No 5 Σ 15

This pair was measured because of the smaller angle found by Se My measures do not confirm the change there indicated —

	°	″	
Σ	P = 197·9	D = 4·70	1831·2
Se	191·7	4·57	1857·9
β	197·2	4·61	1877·9

No 6 OΣ 4

Undoubtedly a binary system.

	°	″	
OΣ	P = 206·7	D = 0·59	1845·3
OΣ	187·6	0·55	1854·0
OΣ	172·7	0·56	1861·7
De	184·7	obl	1865·0
β	155·3	0·56	1878·6

The distance appears to remain nearly constant

No. 11 Σ 35

Probably fixed, unless there be a slight retrograde motion. The following are all the measures:—

	°		
Σ	P = 268·3	D = 8·69	1830·2
De.	87·4	7·93	1866·8
β	266·6	8·62	1877·9

No. 12. De. 2.

As a wide pair, this is Σ 39. The large star was discovered by De., in 1867, to be a close pair, and independently detected by Se. There is no change in the distant star, and no other recent measures of AB.

	°	″	
Se	P = 237·0	D = 0·4	1858·0
De	243·1	obl	1867·6
β	241·8	0·89	1877·8.

No 13 *α Cassiopeiæ*

The larger companion, C, makes the double star, ♅ V 18 = Sh 5 = H 1993 No measures of distance in Sh. That in Smyth's *Cycle* is entirely wrong:—

	°	″	
♅	P = 275·4	D = 54·49	1782·0
P	279·8	61·19	1854·8
β	279·8	62·51	1878·6

There appears to be a slow increase in the distance. This star is much brighter than H.'s 14 m. Sm called it 10½, and Piazzi, 9 m The new star, B, is excessively faint.

No. 14 Σ 49.

Probably a small increase in the distance

	°	″	
Σ	P = 321·5	D = 4·49	1830·9
De.	319·7	5·24	1865·2
β	320·8	5·68	1877·9

No. 15. OΣ 18.

Direct angular motion is obvious from the following:—

	°	″	
Ma	P = 90·6	D = 1·02	1843·9
OΣ	94·7	1·34	1855·2
Se.	99·8	1·13	1858·5
De.	106·2	1·55	1866·6
β	116·1	1·39	1877·9

No. 21 *μ Andromedæ.* (AC = H. 1057.)

The only apparently accurate observation of distance is that of Challis, given by Sm. in the *Cycle*.—

°	″	
P = 110·5	D = 49·19	1842·7.

The nearer star, B, is very much fainter than H.'s companion.

No 22. Σ 76.

But little evidence of change With the exception of a single observation by Ma , the following are all the measures —

	°	″	
Σ	P = 198 1	D = 2 72	1830 5
β	200 1	2 84	1877 9

No. 25. 72 *Piscium.*

I have seen the companion very fairly with the 6-inch refractor The only other measure is H , P = 265°·6 . D = 30″±

No 26. φ *Andromedæ* OΣ 515.

The only other measures of this difficult and interesting system are found in the *Pulkowa Observations*. De found it single in 1865 and 1867 The following are the mean results of OΣ —

	°	″	
OΣ	P = 309 9	D = 0 53	1851 5
OΣ	303 9	0 51	1856 9
OΣ	302 6	0 56	1864 7
OΣ	267 2	obl	1875 1
β	273 0	0 2	1877 7
β	272 3	0 28	1878·8

The last measure made after the foregoing was in type.

No. 27. β 235.

The three wide stars, A, B, and C, with the companion to the latter, make OΣ 24. In 1874 the large star, A, was found with the 6-inch to be composed of two nearly equal stars, and a minute attendant to B detected. There seems to be no change in the old members of the system. My distance of the close pair is certainly too large. By a mean of six observations by De we have .—

	°	″	
De.	P = 74 0	D = 0 45	1875 6.

For the other components the same observer finds :—

	°	″	
C and *c*	P = 48 9	D = 8 00	1868·0
A and B	287 9	43 81	1868·7
A and C	66 9	60·86	1868·0

No. 28. Σ 95 = H. 324.

DE failed to see the companion in 1864–5, as I did in 1873. In 1874 the 6-inch showed at once the small star. There is no indication of motion.

	°	″	
Σ	P = 310.9	D = 14.05	1829.9
β	309.6	14.18	1877.8

No. 29. OΣ 28.

Angular motion is probable.

	°	″	
OΣ	P = 324.4	D = 0.53	1847.6
DE	314.7	0.92	1867.4
β	314.0	0.85	1878.7

No. 30. H. 1076.

No observations since H., who gives—

	°	″
A and B	P = 165.9	D = 4±
A and C	258.0	25±

The distances are largely under-estimated. H. notes it "difficult," and I found B very faint.

No. 31. *Polaris.*

Some three years ago the discovery by M. DE BOE, of Belgium, of two small companions about 4″ distant was announced, and several observers subsequently claimed to have seen them in the described places. The alleged discovery and verifications were made with small apertures, not much exceeding in any instance 6 inches. After having failed with my 6-inch Clark refractor to see the least trace of any star nearer than the old companion, I had very little expectation of seeing them with any aperture. *Polaris* was examined once or twice previous to the occasion noted in the measures, but the conditions were not particularly favourable. At this time the air was very steady and transparent, allowing the use of the highest powers There was not the slightest suspicion of any star within the distance of the well-known companion, and I have no hesitation in saying these supposed new stars do not exist It would be simply impossible to overlook anything of that description under the circumstances

No 35 ΟΣ 30

There is probably no change in the relations of the nearer components I noticed another very minute companion to B, 154° 0 20″±

	°	″	
ΟΣ	P = 235 7	D = 4 62	1855 7
Dᴇ	240 5	3 82	1866 6
β	238 9	4 55	1877 7

No 36 Σ 132 = ♅ IV 130

The great change in this pair is due to proper motion Some of the measures are —

	°	″	
♅	P = 27 7	D = 15 82	1783 6
Σ	5 4	24 25	1829 9
Dᴇ	356 2	30 99	1863 8
β	354 6	33 86	1878 0

No. 37 ΟΣ 32

The companion, which is faint with moderate apertures, was not seen by Dᴇ. The large star at one time was suspected to be a close pair. On both occasions I found it apparently round The following single observation by ΟΣ is all there is for comparison:—

	°	″	
ΟΣ	P = 135 4	D = 9 51	1847 2
β	134 0	8 92	1878 7

No. 38. Σ 145.

Very little attention has been given to this pair since Σ It has been overlooked by all but Mᴀ. There is probably no change

	°	″	
Σ	P = 31 6	D = 11·28	1832 8

No. 39 Σ 196.

The following are the principal measures of this pair:—

	°	″	
Σ	P = 55 5	D = 2 37	1832 4
De	57 3	2 17	1866 8
β	52 0	2 49	1877 7

No. 40 ε *Trianguli.* Σ 201

This fine pair has been wholly neglected by recent observers Change is not very decided.

	°	″	
Σ	P = 119 6	D = 3 72	1833 1
β	116 8	4 10	1877 8

No 42 61 *Ceti* ♅ V 102.

It is evident that one of the distances of ♅ must be in error. I do not find any other measures except the reference in Sm :—

	°	″	
♅	P = 190±	D = 34 50	1783 2
♅	193 7	37 88	1783 6
β	193 3	42 71	1877 9

No. 43. Σ 223.

There is but little evidence of change in the two observations since Σ

	°	″	
Σ	P = 48 3	D = 0 65	1831 0
OΣ	51 9	0 83	1847 0
β	50 7	0 78	1878 7

No 46. ο *Ceti* (Mira)

The nearer star, B, between A and C has not before been observed There is but little change in ♅'s companion.

	°	″	
♅	P = 92 5	D = 114 60	1782 6
P	84 9	117 9	1856 1
β	82 8	115 62	1877 8

The new companion is very faint

No. 48 84 *Ceti* Σ 295

There is certainly some change in angle, but the distance remains nearly constant Some of the measures are:—

	°	″	
Σ	P = 334·6	D = 4·85	1831·9
DE	324·7	4·63	1864·0
β	324·3	4·73	1877·9

No 49. Σ 293

Motion in angle and distance is clearly shown The following are all the measures:—

	°	″	
Σ	P = 57·5	D = 6·61	1830·9
MA.	68·6		1852·6
DE.	71·2	7·67	1866·1
GL	71·0	7·7	1874·0
β	75·3	8·30	1878·6

DE. in 1867·6 found the companion invisible. The change is probably due to proper motion.

No. 50. Σ 303

Attention was called to this pair from the change shown by the measures of SE. It is not confirmed by my observation :—

	°	″	
Σ	P = 180·6	D = 5·65	1831·2
SE.	176·9	5·54	1858·5
β	181·9	5·87	1877·8

No 52. η *Persei*

There are several distant companions to this well-known pair, one of which was found to be double by Mr. I. W. WARD, of Belfast, with an aperture of only 4·2 inches Most observers will require a larger instrument to even glimpse it. There is a 13 m. star about 20″ from C in the direction of 228°·2.

No 53 Σ 310

H in 1827 noted this pair as “ not seen double ” There are no other measures since Σ, and no evidence of change :—

	°	″	
Σ	P = 86·3	D = 2·54	1832·1
β	87·6	2·62	1877·9

A new pair in the field will be found in the list of new stars (No 523).

No. 54 OΣ 46 = H 656.

This star has a closer component, De 73°·9 : 4″·80 (1869·9), not mentioned in II. 656, and the star measured, which makes H 's pair, was not seen by OΣ The angle was not measured by H

No. 55 *τ Persei.*

My attention was called by Mr D W. Edgecomb to the small star, B, in measuring which a still fainter attendant was detected near B. On this occasion it was too difficult to attempt measures of distance

No. 56 Σ 330

The only measure since Σ makes the distance decidedly less The recent measures do not substantiate any change in distance or angle —

	°	″	
Σ	P = 191·1	D = 8·78	1832·7
Ma	192·4	7·66	1844·0
β	191·5	8·69	1877·9

No. 57 Σ 332

It seemed probable that there was an error of 20° in the angle of Ma., and my observation confirms this supposition There are no other measures recorded since those of Σ —

	°	″	
Σ	P = 52·9	D = 12·68	1831·4
Ma	33·2	12·0	1844·1
β	53·4	12·52	1877·9

No. 59 Σ 355.

Change is at least doubtful

	°	″	
Σ	P = 148·9	D = 2·75	1832·5
Se	142·6	2·65	1857·1
β	147·8	2·64	1877·9

No 61. Σ 358

This pair has been entirely neglected of late years The components are probably relatively fixed.—

	°	″	
Σ	P = 349·2	D = 15·22	1833·1
β	350·3	15·59	1877·9

No 63. 94 *Ceti.* H. 663.

This fine unequal pair, from its difficulty or some other reason, has been avoided by all previous observers, except De I have seen the companion with the 6-inch several times, but it is a rather severe test H. only estimated the angle and distance De. calls the small star 11·5 m. and notes it, "very difficult." Giving the estimates of H. their usual accuracy, there is no great amount of motion:—

	°	″	
H	P = 255±	D = 6 ±	
De.	253·1	5·09	1871·0
β	250·9	5·73	1878·0

No. 66. *Tauri* 39. Σ 430.

A and B are relatively fixed, but the distance of C is less than found by Σ. There are no other measures:—

	°	″	
Σ	P = 301·9	D = 39·40	1831·2
De.	301·0	37·76	1863·1
β	301·0	37·74	1878·0.

Is Σ's distance a misprint for 37″·40?

No. 68 OΣ 61 *rej.*

An elongation of this star was suspected by OΣ in 1842, and a 10 m. star at 1″·2 suspected in 1844, but it was rejected in the revised Pulkowa Catalogue of 1850 It was readily seen and measured by De, and OΣ suggests a possible variability in the light of the small star. I found it as described by De The following are all the measures:—

	°	″	
De	P = 125·9	D = 1 93	1867 0
β	127 8	1 87	1877 9

No 69. Σ 449

As the only measure of this pair made since Σ showed some variation, it was measured by me on two occasions There is but little evidence of change.—

	°	″	
Σ	P = 330 9	D = 6 79	1832 2
Ma	326 8	6 0	1843 1
β	330 8	6 94	1877 9

No. 70. *Atlas Pleiadum.* Σ 453

The observations of Σ show this star to have been a very close pair in 1830. All observers since, including Da, De., Se, and many others, have invariably found it single I have examined this star many times in the last five years, with the 6-inch, under very favourable circumstances, and always found it perfectly round. With the 18½-inch, on this occasion and at other times, it presented the same appearance The observations of Σ made the change quite rapid, and if really double, it must have been apparent at some time during the last fifty years From all the evidence, I think it is more than probable that the elongation measured by Σ was not real.

No. 71. 30 *Eridani* H 338

De. suspected an elongation of the principal star in 165°, but I found it apparently round H called the small star 17 m, Wn 9–10, and De 10 5. I always found it very easy with the 6-inch. Not measured by H, and the following are all the measures since.—

	°	′	
Wn	P = 136 8	D = 8 28	1863·8
De	135 2	8 17	1864 4
β	135 3	8 34	1878 0.

No. 72. Σ 475.

No other measures since Σ. Some change in angle is probable.

	°	″	
Σ	P = 15·9	D = 7·48	1831·0
β	22·5	7·34	1877·9.

No. 74. OΣ 531.

According to OΣ this star has the same considerable proper motion as 50 *Persei*, 12′ distant. Relative motion in the components seems well established. I found a new pair in the field, closer and much more difficult. It is No. 545 of the preceding list of new pairs. The following are all the measures of OΣ 531:—

	°	″	
OΣ	P = 147·9	D = 3·30	1855·5
De	139·3	2·75	1875·9
β	138·5	2·60	1878·6

No. 77. *μ Persei*. OΣ 73.

There is a distant star, *sp.*, which makes ♅ VI. 20 and Sh. 364. A faint star *sf* is nearer than this. The closer component is very minute, and was not seen by De. The only measures for comparison are:—

	°	″	
OΣ	P = 349·2	D = 15·07	1851·1
β	348·6	14·88	1878·1.

No. 78. OΣ 77.

This is undoubtedly a binary system, but at all times so difficult that the measures are rare. The following are all the measures:—

	°	″	
OΣ	P = 338·2	D = 0·37	1846·1
Ma	330·1	0·35	1846·1
Ma	337·3	0·3	1852·2
Se.	250°±	Allung.	1859·0
De	Pas du tout mesurable		1867·
β	249·3	0·44	1878·5.

The distant companion (OΣ 41°·7 56″·49; 1847·2) I strongly suspected, on the occasion of the first measure of AB, to have an excessively minute star about 0″·7 distant in the *sp* quadrant I was not able to see it afterwards, under tolerably favourable conditions, when the close pair was well separated, but nevertheless I believe it exists, and that it will be yet seen

No 79. 40 *Eridani* Σ 518

One of the most interesting of the stellar systems, from the large proper motion, and the physical relation of the distant double companion with the principal star. Like many others, this has been neglected by double star observers until recently My last measures were made after this work was in type The following are about all the measures of A and B —

	°	″	
Ḩ	P = 326·7	D = 4·08	1783·1
Σ	287·7		1825·1
OΣ	155·8	3·91	1851·2
OΣ and WN	144·7	4·38	1866·1
OΣ	137·0	4·27	1873·8
DE	127·0	4·27	1877·7
β	128·2	3·92	1877·8
O S	129·2	3·61	1877·8
β	125·4	3·66	1879·0

The distant star I have measured does not partake of the proper motion of A. The only measures are —

	°	″	
WN	P = 185·0	D = 75·85	1864·8
FLM.	148·0	37·2	1877·1
β	145·6	37·10	1877·8
β	137·3	35·99	1879·0

No 82 Σ 547.

This pair has not been measured or seen by anyone since Σ. DE failed to see the companion in 1865, and it was invisible with the 6-inch in 1873, 1876, and early in 1877 The change is very decided The last is a mean of four later measures:—

	°	″	
Σ	P = 344·3	D = 4·25	1831·4
β	9·8	2·46	1877·9
β	14·0	2·25	1879·0

No. 83 80 *Tauri.* Σ 554.

For several years this has been a very difficult pair, and generally too severe a test for the 6-inch. The change is principally in distance There are no other recent measures —

	°	″	
Σ	P = 12 9	D = 1 74	1831 2
OΣ	8 4	1 61	1851 8
De	7 2	1 23	1863 0
Hd	4 7	0 75	1868 1
β	7 0	0 60	1878 0

Undoubtedly a physical pair, as the two components have a considerable common proper motion

No 84. Σ 571 = ♅ III 95 = H 345

Probably unchanged Apparently an error of 10° in angle of Se. There is a faint distant star, 200° 3 : 46″·6 (1878 0).—

	°	″	
♅	P = 260 7	D = 15 35	1783 7
Σ	258 7	17 84	1830 7
Se	268 9	17 54	1858 0
β	258 2	17 30	1878 0

No. 85. Σ 596.

The measures indicate a slow direct motion.

	°	″	
Σ	P = 280·8	D = 11·12	1831·1
De.	284·3	10 28	1865 7
Gl	283 5	10 4	1874·0
β	287 3	10 75	1878 0.

No. 86 Σ 609 = H. 686.

De. found it single in 1865, and I failed to see it with the 6-inch, under excellent conditions, in 1874. On a later occasion, however, it was very plain There is only my observation to compare with Σ ·—

	°		
Σ	P = 82 1	D = 1 93	1832 1
β	75 6	2 70	1878 1.

No 87. Σ 607.

DE in 1866 notes, "Aucun satellite supérieur à 11·5," and I could not glimpse it with the 6-inch in 1873. The stars seem to be relatively fixed

	°	″	
Σ	P = 249 9	D = 14 21	1831 1
H	248 0		(6th Catalogue)
β	250 3	14 12	1877 9

No. 89. 5 *Aurigæ* OΣ 92.

Probably a binary system.

	°	″	
DA	P = 233 3	D = 2 92	1847 1
OΣ	230 1	2 78	1849 1
DE	241 3	2 82	1867 4
β	247 4	2 78	1878 0

No. 91. OΣ 100 = H. 693

The change, if any, is slight. This pair was not measured by H.:—

	°	″	
OΣ	P = 247 2	D = 4 32	1848 5
DE	249 8	4 09	1867 4
OΣ	253 3	4 26	1871 2
β	248 8	3 80	1878 1

No. 92 OΣ 517.

A minute star discovered by Professor HALL with the Washington 26-inch. The only measure to compare with is —

	°	″	
HL	P = 131 6	D = 6 70	1876 1

The large star is a close pair (OΣ 517), but seeing too poor on this occasion to measure it

No. 93 α *Aurigæ*. (♅ VI. 30 = H. 2256 = SH. 51)

B is a faint star nearer than the old companion. Subsequently a still nearer attendant was detected, 317° 5 : 78″·17 (1878 9)

	°	″	
♅	P = 151 4	D = 169 10	1783 6

The change is probably due to proper motion I am not acquainted with any modern measures. Sh. connect a very distant 9 m star.

No 95. τ *Orionis.* (AB = ♅ V 25 · AC = H 2259)

I found ♅'s companion, B, double with this instrument There appears to be no change in B and C·—

	°	″		
Hl	P = 49 3	D = 3 77	1876 2	B*b*
	250 1	35 98	1876 2	AB
	59 8	35 97	1876 2	AC

There may be an error in reading my first angle of the small pair. The new star would be at least 16 m of H's scale Edgecomb sees it well with 9·4-inch H. gave the angles of B and C, 250 4 and 63° 8, respectively

No 96. *Orionis* 82 (AC = ♅ IV. 87 = S 475 = Σ 692)

The large star was found to be a close pair with the 6-inch in 1874. The only other measures of this are by De The following is a mean of his four observations, and a late measure of my own·—

	°	″		
De.	P = 355 3	D = 0 61	1876 1	Mags 7 9 . 8 7
β	2 9	0 50	1878 1	

There is no change in the wide pair.

	°	″	
Σ	P = 4·2	D = 34 86	1831.5.

No. 97. Ma. 1.

The first of a short list of new pairs by Ma. in *Dorpat Observations*, (Vol. xi.) The distant star not in Ma.

	°	″	
Ma	P = 158 8	D = 3. 20	1843 2

No 98. Σ 693.

No other measures since Σ. Probably unchanged

	°	″	
Σ	P = 8 9	D = 3 65	1831 1
β	12 5	3 87	1877 9

No 99. 115 *Tauri.* OΣ 107.

Probably fixed, unless a small advance in the angle.

	°	″	
OΣ	P = 304 9	D = 10 15	1849 5
Dε	307 6	9 89	1867 9
β	308 4	10 18	1877 9

OΣ speaks of a third star, smaller than B, in about 335°, which I did not see on this occasion, with full moon.

No. 100. 114, *o*, *Tauri.* (AC = ♅ V 115.)

No measures in H , and nothing since, but ♅ gives for AC:—

	°	″	
♅	P = 192 1	D = 51 57	1783 7

There is a faint 5″ pair in the direction of 218° 5

No. 101 β *Leporis* β 320

The angular change of this pair is very apparent each year since its discovery in 1874 The annual motion appears to be about 10°. The distance seems to remain unchanged. The following are the measures of each season:—

	°	″	
β	P = 269 1	D = .	1875 00
Dε	267 1	2 89	1875 11
Dε	268·4		1875 08
Dε	279 9	2 71	1876 07
Dε	280 2	2·86	1876 08
Hl.	279·7	3 12	1876 11
Dε	288 8		1876 76
Dε.	289 3	2 91	1876 78
O S	287 2	2 67	1877 09
Hl	284 8	3 16	1877 10
β	289 4	.	1877 10
Dε	293 6	3 06	1877 15
Shp	282 4	2 75	1877 19
Dε.	294 4	3 01	1877 76
β	288 3	2 68	1877·89

No 102 32 *Orionis* Σ 728

Probably a physical pair. It is now a difficult pair, and apparently closing up. Some of the measures are —

	°	″	
♅	P = 217 8	D = .	1782 0
Σ	203 7	1 04	1830 9
Da	205 1	0 89	1844 9
De	192 2	Con	1863 3
OΣ	189 2	0 59	1874 2
β	196 2	0 45	1878 0

No. 103. *α Leporis.* H 3766.

There is no change in the angle of H 's distant companion.

	°	″	
H	P = 154 8	D = 25 ±	
O S	156 1	35 66	1877 1
β	154 8	36 02	1877 9

No 104. *θ' Orionis.* Σ 748.

There is but little change in the small stars, although some of the measures are very discordant. The present measures may be compared with the following.—

Fifth Star.

	°	″	
Σ	P = 353 6	D = 3 86	1832·5
OΣ	350 1	4·27	1863 3
β	354 3	4 02	1877 9

Sixth Star

	°	″		
Da	P = 125 9	D = 3 62	1844·7	
OΣ	128 8	3 73	1858 8	
De	126 0	3 96	1867 0	
β	119 8	3 74	1877 9	
Hl	121 4	3 98	1878 0	(14 nights)

Several observers have seen, or believe they have seen, other minute stars in the trapezium, most of them using comparatively small apertures. While making the measures given above, and at other times, under very favourable conditions, the interior of the trapezium and the vicinity of the principal stars were carefully examined. There was not the slightest suspicion of any additional stars. If the sixth star itself had been double, with a distance of 1″·0, it could not have been overlooked. I have very little faith in the real existence of these suspected stars after the failure of this and other large refractors to show them. It is wholly improbable that they should all be variable in such a manner as to render them at all times invisible within the last few years. In regard to the alleged variability of the fifth and sixth stars, I can only say that they have always been readily seen with my 6-inch glass in the last six years when the atmospheric conditions were suitable. So far as my own observations go, there appears to be no evidence of change in the light of these stars.

No. 106. *Leporis* 45. β 321.

The five principal stars constitute H. 3780, given in H. as "Classes 6 and 7," without measures. Together they are just visible to the naked eye, and rated by Heis, 6–7 m. Two of these stars were found with my 6-inch to be close pairs. The minute star, χ, was added by Hl.

No. 107. Σ 782.

The change is probably due to proper motion.

	°	″	
Σ	P = 309·4	D = 36·16	1831·2
De	308·6	38·66	1866·7
β	307·9	39·44	1877·9

No. 110. OΣ 119.

The following are all the measures:—

	°	″	
Ma	P = 306·4	D = 0·55	1843·2
OΣ	303·9	0·64	1848·6
De	316·7	0·50	1867·6
De	316·3	0·60	1873·9
β	315·4	0·69	1878·1

No. 113 *ν Aurigæ* V 90.

In the collected list of all the double star observations of ♅ the position angle is given 331° 8 In the way then employed of reckoning angles, this would correspond to 61° 8 *sp*. Assuming the quadrant to be *np*., as it certainly was, the agreement is complete In this, as in many other instances, the measures of Sm. in distance are altogether wrong. There is no other evidence of any change. Correcting the angle of ♅ as above, the measures stand:—

	°	″	
♅	P = 208 2	D = 53 72	1783 2
Sm	201 9	85 0	1833 7
β	207 0	54 97	1877 8

No. 114. De 10. (AC = Σ 808)

The close star was discovered by De. in 1869 There is no change in Σ's. companion The only other measures of AB are by De.

	°	″	
De.	P = 164 5	D = 2 72	1871 7
β	164 8	2 56	1877 8.

No. 116. *α Orionis* (AC = ♅ VI. 39.)

The new star is something less than half the distance of ♅'s. companion. The mean value of the measures is :—

	°	″	
β	P = 348 0	D = 77 59	1877 9

A single measure of C was made:—

	°	″	
♅	P = 152 3	D = 161 77	1786 9
β	152 3	174 7	1877·9 single distance.

No. 117. S 503.

The change in AB, from proper motion, is very remarkable.

	°	″	
S	P = 134 1	D = 39 94	1825 1
De	120 3	8 23	1873·8
De	118 6	7 07	1875 2

(See De., *Astr. Nach.* 2045.) The star I have measured is much nearer than C of S., and rather faint.

No. 118. OΣ 121.

A close and difficult pair. De suspected elongation in 190° in 1866. There is some change in the angle. The following comprise all the observations:—

	°	″	
Ma	P = 199·0	D = 0·27	1843·3
OΣ	191·4	0·39	1849·6
β	185·3	0·32	1878·1

No. 119. θ *Aurigæ*. OΣ 545.

There are two distant stars which make ♅ V. 89 = ♅ VI. 34 = Sh 68. The close star forms one of the recent additions to the Pulkowa Catalogue. The only measures are:—

	°	″	
OΣ	P = 5·5	D = 2·15	1871·4
De	3·2	2·05	1875·9
β	3·8	1·90	1878·0

As a 6-inch aperture shows the small star perfectly, it is a little strange that it should have been so long overlooked. There seems to be some change in the distance of C:—

	°	″	
♅	P = 286·0	D = 35·30	1783·7
De	292·4	45·27	1875·7
β	292·7	45·51	1878·0

No. 121. Σ 826.

Some change in both angle and distance.

	°	″	
Σ	P = 115·5	D = 1·84	1832·4
De	122·2	2·22	1867·4
W. S.	128·0	1·77	1875·2
β	125·7	2·18	1877·9

No. 122. Σ 848.

The stars measured by Σ appear to be relatively fixed. The small star is nearer than C and D of Σ. The only other measure is:—

	°	″	
Du	P = 296·5	D = 15·16	1872·2

No 124. Σ 903.

No other measures since Σ. The small difference in distance is hardly sufficient to make any change probable

	°	″	
Σ	P = 294 3	D = 23 32	1829 7
β	294 3	22 73	1878 2

No. 125. Σ 910.

Slow retrograde motion is probable

	°	″	
Σ	P = 170 9	D = 0 67	1829 5
SE	165 6	0 6	1857 1
DE	165 6	0 7	1869 1
β	162 5	0 93	1878 2

No 127 Σ 943 = S. 527.

The considerable movement shown here is probably due to the proper motion of the larger star.

	°	″	
Σ	P = 165 9	D = 15 46	1829·7
MA	152 8	16 40	1844 2
DE.	148 5	18 00	1864 7
β	147 4	19 65	1878 2

No. 128. H. 397

H. records two companions, 30°± : 25″±, and 50°± : 40″±, with magnitudes 19 and 13 respectively, which was overlooked in making the measure, and the other companion not sought for The one measured is smaller than 13 m of H.

No. 130. Σ 955.

Change is not very well marked.

	°	″	
Σ	P = 272 6	D = 0 88	1830·6
SE.	276 3	1 09	1857·1
DE	267 4	1 0	1869 5
β	272 2	1 00	1878 1

No change in the third star, C. There is a faint star about 15″ *s.* of it.

No. 131 **OΣ 154.**

The distance is steadily diminishing in consequence of the proper motion of A.

	°	″	
OΣ	P = 136·3	D = 30·28	1848·8
OΣ	131·5	29·28	1861·3
De	131·7	28·76	1867·9
De	129·2	27·78	1877·3
β	129·0	27·77	1878·0

No 132. **OΣ 155.**

The movement is apparently rectilinear. The distances in my observations appear to be too small:—

	°	″	
Ma	P = 260·0	D = 13·61	1843·3
OΣ	262·1	14·91	1854·5
De	260·4	15·36	1867·8
Flm	261·0	16·10	1877·8
β	259·7	15·07	1878·1

No. 133. *Sirius.* A.G.C. 1

For comparison we have measures with the Washington 26-inch.—

	°	″	
β	P = 52·4	D = 10·83	1878·0
Hl	51·7	10·76	1878·2

No. 135. A C. 4

The following are all the measures:—

	°	″	
J	P = 286·5	D = 1 ±	1858·1
O S	290·8	0·93	1877·1
β	295·4	1·10	1878·0

No. 136. 15 *Lyncis*. OΣ 159.

A binary system in rapid motion. It has been very carefully and regularly observed at Pulkowa :—

	°	″	
OΣ	P = 323·4	D = 0·53	1844·0
OΣ	341·6	0·49	1859·3
De	354·9	Obl	1867·9
β	361·0	0·48	1878·1

The third star, C, is not mentioned in any of the earlier observations. It is a very faint object.

No. 137. OΣ 160

Noted by De. in 1867, "aucun compagnon," and my 6-inch failed to show it under excellent conditions in 1876. The following are all the measures:—

	°	″	
Ma	P = 154·7	D = 1·0	1843·3
OΣ	167·1	1·26	1848·2
β	174·2	1·43	1878·1

No. 140. 41 *Geminorum*. OΣ 162 *rej*

Rejected in the revised edition of 1850 of the Pulkowa Catalogue, and not measured by **OΣ**. De. could not see the companion in 1866, and it was beyond the reach of the 6-inch when examined by me in 1875. There is but a single observation prior to my measures. If both sets are reasonably accurate, the change is very marked.

	°	″	
Ma	P = 164·9	D = 13·5	1843·3
β	154·8	20·98	1878·2

No. 141 ε *Canis Majoris*.

The measures are very discordant, largely due, perhaps, to the low altitude of the star in northern latitudes. The following are all I have been able to find :—

	°	″	
Maclear	P = 160·6	D = 7·48	1850·1
Se	159·3	7·15	1856·1
Se	155·1	5·20	1866·3
O S	162·0	7·65	1877·1
β	160·2	7·42	1878·2

Probably without change.

No. 143 45 *Geminorum*. OΣ 165

A system in rapid angular motion, with a slow decrease in distance The companion is so minute that it was not seen by De in his measures of the OΣ stars Under the best conditions it was invisible with the 6-inch in 1875. The only measures prior to mine are those of OΣ.

	°	″	
OΣ	P = 130·7	D = 3·87	1847·2
OΣ	119·3	3·35	1856·7
OΣ	89·7	2·89	1870·2
β	78·1	2·45	1878·1

The change is probably due to proper motion

No 144. Σ 1031.

No other measures since Σ, probably unchanged H. added a 14 m star, 12″± distant The conditions were not favourable enough on this occasion to measure it.

	°	″	
Σ	P = 251·6	D = 3·80	1831·2
β	248·3	3·33	1878·2

No 146. Σ 1058

De. could not see any companion in 1865, and on three occasions in 1874–5 I failed with my 6-inch All the stars in the vicinity were carefully examined with the large instrument, but nothing found agreeing with Σ's description, or likely to be his pair Σ gave the magnitudes, 8·2 and 11·7, and as the distance is considerable, an aperture of 6 inches should deal with it readily. If there is no error in the assigned place, this would seem to furnish an instance of the real disappearance of one of the components of a double star, and perhaps the only instance on record. The only measure since Σ is a single observation by Ma.—

	°	″	
Σ	P = 282·7	D = 23·78	1832·2
Ma	283·0	22·47	1844·1

No. 147. *Canis Majoris* 164. Σ 1064.

An uninteresting pair, and now measured for the first time since Σ. There is no material change.

	°	″	
Σ	P = 237·7	D = 15·20	1831·2
β	239·6	14·96	1878·1

No. 148. Σ 1074.

A binary system in rapid movement.

	°	″	
Σ	P = 115·3	D = 0·47	1831·5
OΣ	129·4	0·61	1852·2
De	135·9	Obl.	1863·1
W S	134·2	0·85	1874·1
β	140·0	0·71	1878·0.

I noticed two minute stars, 11°·8 : 15″·9 and 94°·5 : 12″±. (Inadvertently placed in the list of new pairs. *See* β 577.)

No. 149. Σ. 1071.

The distance is steadily increasing. With the exception of two observations by Ma., the following are the measures:—

	°	″	
Σ	P = 357·3	D = 15·52	1829·7
De.	5·0	15·87	1867·3
OΣ	7·7	16·18	1874·3
β	7·3	16·24	1878·0.

No. 150. Σ. 1081.

Slow angular motion, with but little change in distance.

	°	″	
Σ	P = 216·1	D = 1 33	1828 9
DE.	224 6	1 46	1867 8
β	226 1	1 36	1878 1

No 152. γ *Canis Minoris.*

The small star is given in the *Munich Observations*, but has not been measured since by any other observer :—

	°	′	
MU	P = 247 3	D = 34 62	1836 3
β	243 2	32 60	1878 1

No. 153. Σ 1097. (AB = β 332.)

In 1875 I found the principal star of Σ 1097 to be a close pair D is mentioned by H., but not in Σ, and there are no other measures. No change in Σ's pair, AC The fifth star, E, is very faint, and has not been before noticed.

No. 154 H 760.

H. says, "the small star a *minimum visibile*," and estimates, 360°± : 30″± The companion is about what I have called, 12-13 m

No. 155 OΣ 175.

There seems to be an increase in the distance, but the angle remains about the same as when first observed.

	°	″	
OΣ	P = 333 8	D = 0 40	1847 6
DA	329 4	0 5±	1854 3
DE	332 1	0 81	1866 8.

No 156 *Procyon.*

The distant attendant was detected independently by Talmage and Dawes, but it had been seen and measured a long time prior, as will appear from the measures given below The change is due to the proper motion of the large star:—

	°	″	
Mu	P = 262·3	D = 56·59	1836–7
Romberg	294·9	45·8	1863·2
Ne	311·8	44·59	1874·0
β	317·3	44·62	1877·8

When the last measures were made, and at other times, *Procyon* was carefully studied with all powers, but with no suspicion of any nearer star.

No 157 Σ 1142

There is certainly motion, probably rectilinear, but the measures of the last 20 years make the distance about the same —

	°	″	
Σ	P = 275·9	D = 24·36	1829·5
De	262·0	22·83	1863·4
W S	258·1	22·8	1874·2
β	254·5	22·84	1878·2.

No. 158. Σ 1143.

This pair was measured by Σ in his first observation, but not seen on three several nights later, and it has never been seen since, although repeatedly looked for by De in 1863–4, and by myself in 1874–6 The failure of Σ to find it shortly after his measures is tolerably satisfactory evidence that there is some error in the place of the star as entered by him I could not find anything in the immediate vicinity agreeing with his description.

No. 159. Σ 1152.

The only measures are given below:—

	°	″	
Σ	P = 312·9	D = 5·81	1830·7
O.S.	313·5	6·45	1876·0
β	314·1	6·05	1878·2

No 160 Σ 1154

I find no other measures after Σ —

	°	"	
Σ	P = 357·9	D = 2·26	1827·7
β	352·9	2·41	1878·2

No. 161 9 *Argûs* β 101

The measures present some evidence of angular motion, but the discrepancies may be due, to some extent, to the difficulty of the object. The measures of De. are a mean of three observations —

	°	"	
De	P = 289·4	D = 0·51	1875·6
β	302·6	0·41	1878·2

No 162. OΣ 183 *rej.*

No other measures except a single angle by Ma of 14°·5 (1843·3). Companion not seen by De in 1866.

No. 163 *Cancri* 5. Σ 1171.

Except Ma., De is the only other observer who has measured this since Σ. From a comparison of the measures, my angle appears to be too large:—

	°	"	
Σ	P = 338·6	D = 2·80	1828·9
De	330·1	2·49	1864·8
β	333·8	2·93	1878·1

No 164 Σ 1175

Very decided change in angle and distance. It has been neglected since Σ, except by Ma. and De.—

	°	"	
Σ	P = 204·6	D = 2·37	1831·2
De	217·8	2·07	1866·8
β	222·5	1·81	1878·1

No 165 Σ 1213.

There seems to be a diminution in the distance. The following are all the measures.—

	°	″	
Σ	P = 327·6	D = 8·43	1830·9
De	324·0	7·24	1867·7
β	325·1	7·43	1878·2

No. 166. Σ 1216.

The physical relation of the components of this fine pair seems well established Some of the epochs are.—

	°	″	
Σ	P = 115·2	D = 0·45	1831·2
OΣ	139·4	0·49	1851·3
De	151·1	Obl	1863·3
W S	169·3	0·4±	1873·2
Gl	167·0	0·5	1873·2
β	158·8	0·61	1878·2.

No. 167. OΣ 193 = H. 447.

Probably without sensible change.

	°	″	
OΣ	P = 295·1	D = 14·20	1851·0
De	295·7	13·64	1868·1
β	298·1	14·17	1878·0.

No. 168. Σ 1230

A slow increase in distance, with little or no change in angle.

	°	″	
Σ	P = 194·1	D = 28·00	1829·2
De	192·4	29·25	1864·0
Gl	193·0	30·8	1874·2
β	192·7	29·90	1878·2.

Error of 1″ in Gl.? The distance for 1874·2, on the basis of the measures of Σ and De, would be 29″·76.

No. 170. Σ 3119

There is but one other observation since Σ. The motion appears to be rectilinear —

	°	″	
Σ	P = 213·6	D = 24·82	1830·2
DE	214·2	25·98	1865·4
β	215·9	26·21	1878·2

No 171. δ *Cancri.* H 457

The change is attributable to the proper motion of the principal star. During the total eclipse of the Sun of July 29, 1878, I saw this star very distinctly through the corona, at a distance of about 12′ from the Sun's limb. The following are all the measures of H.'s companion The observation of SM is entirely erroneous —

	°	″	
MU	P = 123·8	Δ Decl. 27·94	1836·1
LASSELL	121·1	P = 45·82	1852·3
β	113·9	41·08	1878·2

No. 172 ε *Hydræ.* Σ 1273.

The third star, which is very minute, was detected by HN with the Washington 26-inch. I do not know of any other measures. OΣ suspected an elongation of the principal star in 1860. I could not see any traces of duplicity on this occasion

No. 173. Σ 1281.

The change is evidently due to proper motion :—

	°	″	
Σ	P = 329·6	D = 25·02	1833·5
DE	323·8	29·47	1864·5
β	321·3	31·18	1878·1

No. 174. ρ *Hydræ.* A. G. C. 3.

A minute attendant detected by A. G. C. with the MCCORMICK 26-inch. I know of no other measures. The mean of my three measures is:—

	°	″	
β	P = 144·9	D = 12·40	1878·0

No 176 Σ 1327

Only measured since Σ by De —

	°	″	
Σ	P = 81 4	D = 16 13	1831 3
De	80 2	14 08	1863 3
β	77 8	13 47	1878 1

No. 177. Σ 1329

Another instance of rectilinear motion.

	°	″	
Σ	P = 245 7	D = 27 19	1834 3
De	247 3	23 73	1864 7
β	248 4	22 84	1878 1

No. 178. Σ 3121

One of the most interesting and rapid of the binary systems Doberck (1877) finds a period of 37 03 years This pair has been carefully and systematically measured by **OΣ** and De My distance is certainly too large. It was estimated at the time 0″·25, and as the stars were just in contact with the high power, this estimate cannot be far out of the way ·—

	°	″	
Σ	P = 20 0	D = 0 85	1832 3
OΣ	243 5	0 40	1840 3
OΣ	228 6	0 42	1850 3
De	189 6	0 68	1866 2
De	210 5	con	1872 2
De	214 9	obl	1874 2
De	251 9	oval	1875 3
β	185 2	0 36	1878 2

No. 181. OΣ 207 *rej*

An error in the distance of Ma. would seem probable, as the angle must be increased 180° Possibly some other pair may have been observed for this :—

	°	″	
Ma	P = 146 5	D = 16 05	1843 2
De	322 6	19 06	1867 5
β	323 2	19·24	1878 3.

No 183. 8 *Sextantis* A. C 5

Discovered by A C in 1852 with an aperture of only 4¾ inches. There can be no doubt of its binary character. It is now an excessively difficult pair. The conditions were not very favourable, and the two measures differ widely, and neither of them agree with the single observation of O S The following are all the measures of this interesting system:—

	°	″	
DA	P = 50 5	D = 0 5±	1854 2
DA	38 2	0 5±	1860 3
DE	173 8		1873 3
DE	169 0		1875 3
O S	117 4	0 2±	1878 2
β	161 0	0 2±	1878 2

No 184. 31 *Leonis.*

Discovered by Mr **GEORGE ANDERSON** with the Washington 26-inch. A fine object from the ruddy colour of the large star The companion is a very minute point. The following are all the measures:—

	°	″	
HL	P = 42 4	D = 7 48	1875 3
β	44 4	7 63	1878 2

No 185 *a Leonis*

The minute companion to H 's star was detected by the late Professor **WINLOCK** some years ago with the 15-inch of the Harvard College Observatory The only other measures are by HL :—

	°	″	
HL	P = 85 0	D = 3·17	1876 3
β	88 5	3 29	1878 1

No. 186 Σ 1416 = H. 4293.

I am not aware of any other measure since that of Σ:—

	°	″	
Σ	P = 275 8	D = 11 25	1827 7
β	276 7	11 84	1878 3

No. 187 39 *Leonis* OΣ 523

Common proper motion, and probably physically connected.

	°	″	
OΣ	P = 295·6	D = 6·73	1851·3
De	300·3	6·69	1866·9
β	298·7	6·67	1878·1

No 189. Σ 1423

Angular motion is clearly shown.

	°	″	
Σ	P = 99·3	D = 1·12	1830·9
De	76·8	1·27	1865·2
β	69·7	1·28	1878·2

No. 190 H 4311.

Noted by H "exceedingly delicate" There is no indication of change in the angle.

	°	″	
H.	P = 122·3	D = 4±	
O S	126·3	4·38	1877·1
β	124·3	3·88	1878·4.

No. 191. Σ 1445.

The following are all the measures, except a single observation by MA.:—

	°	″	
Σ	P = 167·4	D = 2·42	1827·6
De	159·4	2·95	1864·9
β	160·0	2·71	1878·3

The earlier measures appear to show that my angle is too large

No. 192 H 165.

Not measured by H. His description is, 330°±: 3″±.

No 193 OΣ 226 *rej*

The only other measure is an angle by MA, 50°·5 (1843·3) The companion is now, as in 1874 when examined with my 6-inch, much smaller than 10 m, and not less than 11·8 m

No 195. De. 14. (AC = Σ 1481).

The close star was discovered by De in 1864 There is no change in the distant star of Σ The only measures of AB are:—

	°	″	
De	P = 193 0	D = 5 93	1864 8
β	194 1	6 02	1878 2

No 196. OΣ 230

There is certainly slow motion in angle, but it is a difficult pair with small apertures:—

	°	″	
OΣ	P = 4 7	D = 8 65	1846 9
De	11 4	8 31	1867 3
β	13 4	8 36	1878 2

No 199. OΣ 234.

Without doubt we have here a binary system in rapid motion, but at all times it is a difficult pair. There is an error of some kind in one of the angles I have given, perhaps in reading the position circle Both measures were made under very favourable conditions, and it would hardly be possible to make the angles so discordant without a blunder of some kind. In the first measure the stars were noted as just in contact with the highest power, and the distance is certainly under 0″ 3 It was examined two or three times afterwards, but the definition was not good enough to make it worth while attempting measures. It will be reobserved at the first opportunity. The following are all the observations of this interesting system.—

	°	″	
Ma	P = 179 6	D = 0 25	1843 3
OΣ	177 5	0 43	1844 7
Ma	14 2	0 28	1847 4
OΣ	188 9	0 37	1848 7
OΣ	200 3	0 31	1852 1
OΣ	243	obl	1858 9
OΣ	257	obl	1861 3
OΣ		single	1866
D		single	1866
OΣ	282	obl	1870 5

No 202. OΣ 243.

On the whole it is doubtful if any material change has occurred.

	°	″	
OΣ	P = 10 9	D = 0 72	1846 0
De	8·9	0 9	1867 9
β	14 5	0 94	1878 3.

No 203. Σ 1607 = H. 202 = H 516

The third star, noted in H. 516, is not in Σ It has not been measured before The distance of Σ's pair is slowly diminishing from the effect of proper motion Some of the observations are —

	°	″	
Σ	P = 350 3	D = 33 07	1831 0
De	355 0	31 35	1863 3
β	358 0	30 85	1878 3

No 205. OΣ 245.

There may be a small advance in the angle.

	°	″	
OΣ	P = 275 1	D = 8 33	1848 1
De.	276 9	8 25	1867 2
β	278 1	7 83	1878 3

No. 206. OΣ 246

Although retained in the revised Catalogue of 1850, it is rejected as single in the published measures of OΣ. De. found it single in 1866, as it certainly was on the present occasion. As a double star it may as well be rejected altogether

No. 207 Σ 1630.

No other measures since Σ.

	°	″	
Σ	P = 166 8	D = 2 32	1832 5
β	171 5	2 59	1878 3

Nos. 209, 210 OΣ 247 *rej* and 248 *rej*

Both rejected as single by OΣ in the Catalogue of 1850, and so found by DE in 1866 I put them in my observing list for the reason MA measured a suspected elongation as follows .—

	°	″	
OΣ 247	P = 26 2	D = 0 25	1848 4
OΣ 248	28 0	0 25	1843 3

I have not the slightest doubt that both stars are really single

No 211. OΣ 249.

There is some evidence of orbital motion in the close pair, as will appear from the following, which are all the measures recorded:—

	°	″	
MA.	P = 330 5	D = 0 40	1843 4
OΣ	315 1	0 53	1853 2
DE	311 4	0 5	1868 0
β	307 1	0 46	1878 3

The third star was not observed by DE. The only earlier measure is that of OΣ

	°	″	
OΣ	P = 149 7	D = 13 23	1855 9
β	148 3	12·68	1878 3

No 212 OΣ 250.

The only measures are as follows·—

	°	″	
MA	P = 335 7	D = 0 42	1843 4
OΣ	330 7	0 44	1846 0
DE	321 3	obl	1868 1
β	329 0	0 47	1878 1

No. 213 Σ 1641

Retrograde motion, with a steady advance in distance With the exception of a measure by MA, the following are all —

	°	″	
Σ	P = 50 4	D = 6 14	1831 4
DE	42 3	7 73	1867 6
β	39 2	8 96	1878 3

No 214 Σ 1643.

Probably binary The only measures since Σ and Ma are given here :—

	°	″	
Σ	P = 71 2	D = 1 94	1830 3
De	54 4	1 79	1864 7
β	46 6	1 76	1878 3

No. 215 Σ 1644

There seems to be a slight change in the distance.

	°	″	
Σ	P = 248 6	D = 21 82	1827 5
De	247 0	21 08	1867 9
OΣ	247 0	20 88	1870 3
β	246 7	21 06	1878 3

No 216 Σ 1675 = H 520.

No other measure since Σ, and probably fixed

	°	″	
Σ	P = 9 6	D = 31 07	1831 4
β	8 2	30 66	1178 3

No. 217 OΣ 255.

Not seen by De in 1866, and no other measures except an angle by Ma., 333° 3 (1845 3)

No. 218 Σ 1682.

The following are all the measures of this wide pair —

	°	″	
Σ	P = 308 8	D = 33 65	1831 6
De	306 9	32 34	1865 3
β	305 8	32 35	1878 3

No. 220. Σ 1702.

The only measure since the observations of Σ shows no change in the components .—

	°	″	
Σ	P = 82 7	D = 35 65	1831 3
β	82 5	35 73	1878 3

No. 221. Σ 1703

A decided diminution in the distance.

	°	″	
Σ	P = 283·1	D = 22·65	1829·3
De.	283·0	19·71	1865·3
β	281·5	18·79	1878·3

No. 222. 46 *Virginis*. A. G. C. 6.

Discovered by A. G. C. with the 12-inch made for the Vienna Observatory. The following are all the measures I am acquainted with:—

	°	″	
Hl	P = 158·9	D = 1·32	1876·4
De.	148·5	1·22	1877·4
O. S.	145·7	1·15	1878·2
β	151·5	1·48	1878·3

The third star not noted before.

No. 224. Σ 1707.

With the exception of Ma., the following are all the measures of this pair:—

	°	″	
Σ	P = 30·9	D = 10·22	1828·9
De	33·0	9·22	1865·3
Flm	34·8	9·00	1877·5
β	35·5	9·84	1878·3

No. 225. Σ 1711.

There seems to be a diminution in the angle and distance.

	°	″	
Σ	P = 355·9	D = 1·43	1829·3
De	348·4	1·28	1863·2
W. S.	352·3	1·13	1876·4
β	349·7	1·06	1878·3

No. 226. H 2638.

H only measured the angle of AB, 209°·6. I could not see C with the 6-inch

No. 227. Σ 1727 = H. 527.

Probably unchanged.

	°	″	
Σ	P = 335·0	D = 7·26	1831·3
β	336·6	7·63	1878·3

No 228. 53 *Virginis*. H. 2645.

The description in H. is 30°± 50″±, "position by diagram." In this, as in most similar pairs, the measures of Sm are entirely erroneous

No. 229. 61 *Virginis* ♅ VI 90

The change arises from proper motion.

	°	″	
♅	P = 345±	D = 73·25	1783·0
Kn	22·6	169·29	1862·3
β	25·2	189·96	1878·3

No 230 Σ 1737 = H 224.

This pair is also ♅ IV. 57, there being an error of 43′ in the Decl. of ♅ No evidence of change

	°	″	
♅	P = 223·5	D = 17·08	1782
Σ	220·5	15·12	1829·3
β	220·2	15·13	1878·3

No. 232. **OΣ** 268 *rej* (AC = ♅ V 70 = H 2657.)

No other measures of AB. For AC we have:—

	°	″	
♅	P = 277·0	D = 56·93	1783·2
De	259·5	67·39	1870·3
β	259·0	67·86	1878·3.

Probably error in the angle of ♅, as H gave 259°·4.

No 233 H 2659

H has only estimates, 315°± 10″±, and adds, "one of the most difficult, but a haze is come on Requires verifying" On this occasion I could not find any companion, but the night was not very favourable

No 234. H 3340

Noted by H. as "very difficult"; 204° 5 . 1″±. It would hardly be safe to infer any change under the circumstances. No other recent observations

No. 235 H. 3341

The only double star ever discovered by Sm, and this was found with one of the large reflectors of H It is a short distance preceding the cluster M 3 I have seen it perfectly with the 6-inch aperture. Da noted it as "excessively difficult" His estimate of the distance is so much at variance with that of H, the evidence of change is unsatisfactory.—

	°	″	
H	P = 190 0	D = 1½±	1835 5
Da	196 9	0 8±	1848 4
β	193 8	2 68	1878 2

No 237. Σ 1775.

The only recent measures indicate no change in the components.

	°	″	
Σ	P = 335 7	D = 27 75	1829 3
β	335 7	27 80	1878 3

No 238 Σ 3081

De failed to see the companion in 1865, and we have no other measures since Σ There seems to be change in the angle.

	°	″	
Σ	P = 76 3	D = 1 97	1830 6
β	67 2	2 02	1878 3

No. 239 *τ Bootis.* **OΣ** 270.

The components have a common proper motion, and are probably physically connected. There is a slow increase in the position angle, and apparently a diminution in distance.—

	°	″	
OΣ	P = 347 8	D = 10 26	1849 5
De	348 9	9 04	1867 4
β	351 9	8 71	1878 3

No 240 Σ 1784.

Neglected since Σ, but probably fixed

	°	″	
Σ	P = 207 1	D = 8 66	1832 5
β	208 7	9 00	1878 3

No 241. OΣ 272

Taken together, the measures do not furnish much ground for suspecting motion, unless in distance —

	°	″	
OΣ	P = 23 5	D = 1 89	1849 6
De	17 8	1 79	1866 7
β	20 9	1 41	1878 3.

No 242 Σ 1791

Overlooked by all late observers It is an insignificant object, and apparently without change

	°	″	
Σ	P = 159 8	D = 20 46	1829 3
β	159 7	21 12	1878 3.

No 243 Σ 1801

Not unlike the last Examined by De in 1865, but the small star not seen My measures indicate a considerable increase in distance

	°	″	
Σ	P = 64 5	D = 18 44	1828 3
β	67 5	19 37	1878 3

No 245. Σ 1805

One of the observations of Ma., credited to this pair, belongs to Σ 1809.

	°	″	
Σ	P = 30 5	D = 4 54	1832 4
Se	34 1	4 96	1856 4
β	34 5	4 70	1878 3.

No. 246 Σ 1809

Probably without sensible variation The measure of Ma is attached to Σ 1805 in the *Dorpat Observations.*

	°	″	
Σ	P = 196 7	D = 4 14	1832 1
Ma	194·9	4 34	1858 4
β	194 8	4 09	1878 3

No. 247. Σ 1820.

The angular motion of this pair is clearly shown.

	°	″	
Σ	P = 47 9	D = 2 40	1834 1
De.	60 5	2 11	1866 7
Du.	63·2	2 27	1871 4
OΣ	68 0	2 64	1874·7
β	67·4	2 32	1878 3

No 248. Σ 1827. (AC = H. 1251)

There is no doubt of angular motion, but some of the measures are very discordant. De found it non-measurable in 1863 —

	°	″	
Σ	P = 118·3	D = 0·44	1830·3
OΣ	128·9	0·58	1850·1
β	131·4	0·65	1878 3.

There are no other measures of C, except H 's angle of 65°·5′.

No. 250. Σ 3083.

The only measures of this pair make the stars relatively fixed.

	°	″	
Σ	P = 230·3	D = 4·55	1832·7
β	230·7	4·48	1878·3.

No. 251. Σ 1843 = H. 2722.

Fixed.

	°	″	
Σ	P = 188·1	D = 20·15	1830·6
β	187·7	20·02	1878·3.

No. 252. Σ 1847.

There has been a considerable change in the components, probably the result of proper motion.—

	°	″	
Σ	P = 248·4	D = 18·73	1829·8
Mh.	253·1	20·17	1848·4
De.	256·0	21·67	1865·4
β	257·8	22·63	1878·3.

No. 253. OΣ 283.

There is but little, if any, change. The last of OΣ is a single measure, and possibly 10° in error:—

	°	″	
OΣ	P = 134·6	P = 4·93	1848·2
De	130·1	5·11	1866·8
OΣ	141·3	5·27	1875·5
β	131·1	5·00	1878·3.

No. 254. OΣ 284.

It seems to be relatively fixed.

	°	″	
OΣ	P = 106·3	D = 6·98	1848·2
De	102·3	6·79	1866·7
β	102·4	7·17	1878·3.

. No. 256 Σ 1874.

No other measures.

	°	″	
Σ	P = 288 4	D = 25 73	1830 6
β	288 6	26 32	1878 3

No 257. Σ 1879.

Probably a binary pair, and now a difficult object De found it single, or a doubtful elongation in 1863–5 My measures show the smaller component to be now in the opposite quadrant to that in which it was when measured by Σ. There should be no mistake about it then, as it was a wide, easy pair, and I am certain there is none now, for the *sp* star was particularly noted as being at least half a magnitude the smallest:—

	°	″	
Σ	P = 67 3	D = 1 18	1830 0
Ma	57 2	0 69	1843 4
Shp	39 1	0 37	1877 4
De	42 9	0 34	1877 5
β	217 1	0 42	1878 4

No. 258. μ *Libræ.* β 106

This very easy pair was found with the 6-inch in 1873. For comparison we have the following.—

	°	″	
De.	P = 335 0	D = 1 31	1875 1
Shp	335 3	1 57	1875 4
O S.	335 8	1 67	1877 4
β	333 2	1 50	1878 3

The third star not noticed heretofore.

No 259 H. 5489

The description in H is, 20°±: 15″± . 6 20 Hl has examined this with 26-inch, and finds no such companion, the nearest being 207° 6: 55″·78 : 6 . . 16 (1875 4). I could not see it on this occasion, and measured a very distant star *nf.*

No. 260. β 31.

A pretty pair, near ξ *Bootis*. The close pair was found with the 6-inch, in measuring which the third star was detected.

No. 261. H 2752

Measured by Ma as new. Evidently fixed.

	°	'	
H	P = 131·2	D = 4½	1830
Ma	126·3	5·44	1843·3
β	126·5	5·84	1878·3

No. 262. P. XIV 212. Sh. 190 = 𝔥 N 2

A system not unlike 61 *Cygni*, having large proper motion, and probably physical relation between the components. Some of the measures of AB are:—

	°	″	
Sh	P = 270·1	D = 10·82	1823·3
H	277·4	12·08	1836·7
Main	283·9	13·51	1862·4
O S	290·2	14·98	1877·4
β	290·8	15·33	1878·4

H noted a 16m star from B, 320° 0·20″±. This is the star F of my measures. The change in angle and distance corresponds to the proper motion of A. In the course of time B and C will form a moderately close pair. C is the faintest star of the group. The distant stars measured by single distances.

No. 263. 59 *Hydræ*. β 239

The only other measures were made with the 6-inch without a driving clock:—

	°	″	
β	P = 123·7	D = 0·8±	1874·5
β	129·5	0·93	1878·4

No. 264. 2 *Serpentis* β 348.

This pair seemed much more difficult than when I found it with the 6-inch in 1875, and appeared closer, although the measures do not show it. There is perhaps some change in the angle.

	°	″	
De	P = 114·0	D = 0·4	1875·5
De.	116·6	0·58	1876·4
Shp	119·0	0·5±	1876·5
β	121·4	0·51	1878·4.

De gives the colours, yellow, ash.

No 265. Σ 1914 = S. 667.

Probably without change. The following are all the measures:—

	°	″	
Σ	P = 336·4	D = 30·94	1827·4
Ferguson	335·7	31·25	1863·5
β	335·8	31·32	1878·3

No. 266 Σ 3091.

There is a very great change in the distance. De. mentions only a doubtful elongation in 45° in 1863, and Hl could find no close pair here with the 26-inch in 1875. I was never able to see the least trace of duplicity with the 6-inch. Hence, it has probably been single and is now commencing to open, but is still very difficult. Se. records a single measure of Σ 3091, 243°·0 : 0″·5 (1859·6), but gives an entirely different place. R.A. 15^h 45^m ; Decl 3° 19′. Certainly that cannot be this pair, or it would have been seen by De in 1863. It is highly improbable that the distance should have remained constant during the 27 years between Σ and Se., and the star become single in the five years succeeding. I carefully examined the place given by Se., and could find nothing of the kind there.

The following are the measures to this date:—

	°	″	
Σ	P = 227·3	D = 0·50	1832·4
β	225·0	0·25±	1878·4

The stars are equal, so that it is not unlikely the real change would be better shown by applying a correction of 180° to the last angle

No 267. OΣ 294

The only measures are as follows:—

	°	″	
OΣ	P = 251·3	D = 3·26	1848·6
De	247·8	3·23	1867·6
β	248·7	2·75	1878·3.

No 269 OΣ 295

The angles are too discordant to make change certain

	°	″	
Ma	P = 114·8	D = 0·77	1843·3
Ma	113·1	0·7	1846·1
OΣ	128·4	0·74	1846·4
De.	122·9	0·85	1866·8
β	128·7	0·75	1878·4

No. 271. Σ 3093.

Decided motion.

	°	″	
Σ	P = 135·5	D = 33·38	1829·4
De.	138·6	31·15	1865·3
β	139·9	30·79	1878·3

No 274 γ *Libræ*.

This distant companion, noted by Goldschmidt, has not been measured before.

No 276 Σ 1961

The change is due to proper motion

	°	″	
Σ	P = 56·0	D = 21·55	1830·6
De.	47·8	22·23	1866·8
β	44·6	22·45	1878·3

No 277. OΣ 298

Rapid orbital motion This has been measured by several observers The character of the movement will be seen from the following —

	°	″	
OΣ	P = 181 6	D = 1 20	1846 5
De	208 9	0 99	1866 4
Du	214 1	0 58	1869 5
OΣ	235 8	0 58	1872 6
OΣ	264 3	0 53	1875 5
De	280·9	0 3±	1876 5
De	295 2	0 3	1877 4
β	310 7	0 27	1878 3

No. 279. Σ 1964 (AB = ♅ IV 61 = H 255 = S. 674)

No change in AB. There are no other recent observations of the close pair.

	°	″	
Σ	P = 8 1	D = 1 34	1830 9
β	10 0	1 34	1878 4

No 280. Σ 3095

The measures given below are all that have been made of this pair

	°	″	
Σ	P = 349 7	D = 2 85	1831 3
De	336 9	2 75	1865 4
β	337 8	2 83	1878 4

No. 282 ε *Coronæ.* A G C 7

This very difficult and unequal pair was discovered in 1876 by A G C with the McCormick 26-inch object-glass Edgecomb sees it easily with a 9 4-inch Clark Refractor, but observers generally will require a much larger aperture The only other measures are given below —

	°	″	
Hl	P = 351 4	D = 2 17	1876 4
β	360 2	1 86	1878 3

No. 283. Σ 2001.

A comparison of the only measures recorded of this pair shows a fixed relation of the components:—

	°	″	
Σ	P = 169.6	D = 11.57	1829.7
β	168.8	11.93	1878.3

No. 284. Σ 2006

There appears to be slow motion in the angle.

	°	″	
Σ	P = 204.5	D = 1.61	1830.9
De	197.4	1.65	1869.3
β	196.8	1.66	1878.4

No. 285. ν *Scorpii.* β 120.

The conditions were not very favourable, and my distance may be too large, but the close pair is much easier than when I found it in 1873, when it was estimated 0″.4, and I have no doubt it is opening —

	°	″	
β	P = 357.7	D = 0.4±	1874.4
De	359.5	0.59	1875.1
De	360.6	0.79	1877.5
β	363.7	1.04	1878.3

For measures of the wide pair (H V. 106), and of the double companion, with details of measures of AB, see *Monthly Notices*, November 1874

No. 286. Σ 2022

Perhaps some angular movement.

	°	″	
Σ	P = 129.5	D = 2.77	1830.6
OΣ	138.7	2.78	1868.5
β	136.4	2.89	1878.4.

No. 288. Σ 2036. (AC = H. 3345.)

H. does not mention the close star, nor Σ the distant one. As the place given by H. is almost exactly that of Σ, I suspected the principal star of both pairs might be identical, but was never able to see the small star with the 6-inch. The description in H. is, 339°·9 · 12″± : 9 . . . 16; "excessively difficult, but hazy." With the large aperture it was of course readily seen, and found to belong to Σ 2036. Of the latter I find no other measure. The difference in the angles is too great for errors of observation in a pair of this kind:—

	°	″	
Σ	P = 235·3	D = 2·01	1832·3
β	241·5	2·18	1878·4

No. 290. η *Draconis*. OΣ 312.

Some change in distance is probable.

	°	″	
OΣ	P = 144·0	D = 4·67	1843·7
OΣ	142·3	4·86	1851·2
De.	141·2	4·85	1866·3
OΣ	145·5	5·20	1873·7
β	141·7	5·26	1878·4

Rogers suspects variability in the small star.

No. 291. Σ 3105.

Apparently slow retrograde motion.

	°	″	
Σ	P = 57·5	D = 0·62	1835·6
De.	53·2	0·5	1870·0
β	50·9	0·61	1878·5.

No. 292. Σ 2062.

If not variable, the companion is certainly smaller than 10 m., as found by Σ. De. could not see it under excellent conditions in 1865·3. In April 1874 it was seen by me with the 6-inch, but difficult; in June 1874 it was invisible on a first-class night; and in May 1875 it was well seen with high powers. There is no reason to suspect any change in either angle or distance. The following are all the measures I have found :—

	°	″	
Σ	P = 112·9	D = 2·30	1832·1
Se	114·5	2·11	1857·0
β	114·2	2·80	1878·4

No. 294. Σ 2092.

No other measures.

	°	″	
Σ	P = 5·9	D = 8·04	1831·1
β	5·2	8·18	1878·4

No. 295. Σ 2106.

The angle is certainly less than found by Σ, but the later measures are very discordant in angles:—

	°	″	
Σ	P = 337·5	D = 1·01	1827·3
De	321·3	0·5	1863·5
OΣ	322·8	0·67	1871·8
W. S	309·7	0·5±	1873·5
Gl	310·9	0·5±	1874·4
W. S.	329·8	0·4±	1875·6
β	323·7	0·64	1878·4

No. 296. Σ 3106.

The motion indicated by the single observation of Se. is not supported by my measures:—

	°	″	
Σ	P = 246·5	D = 2·35	1831·9
Se.	250·6	2·20	1859·5
β	246·8	2·19	1878·5

No. 297. OΣ 317.

The change appears to be due to the proper motion of the large star, which, according to OΣ, is −0″·025 in R.A. and +0″·096 in Decl.

	°	″	
OΣ	P = 234 5	D = 15 73	1848·7
OΣ	226 4	16 91	1874 7
β	228 5	17 30	1878 3

No 299. Σ 3107.

Retrograde motion in angle.

	°	″	
Σ	P = 112 3	D = 1 59	1831 9
DE	104 4	1 32	1864·5
β	100 1	1 38	1878 5.

No. 300. OΣ 321.

Probably without sensible change.

	°	″	
OΣ	P = 1 7	D = 0 51	1848 8
DE.	5 2	obl	1866 4
β	2 6	0 55	1878 5

No 301. Σ 2117.

Companion not seen by DE. in 1863 Probably fixed. The only measures are:—

	°	″	
Σ	P = 117 0	D = 1 36	1831 5
MA.	113 7	1 15	1843 6
β	116 3	1 29	1878 3

No. 304. 60 *Herculis* H V 133.

There are no other observations of this distant companion since H, except those found in SM :—

	°	″	
H	P = 307 0	D = 48 67	1783 2
β	309 8	53 38	1878 5

No. 308 OΣ 327.

No certain elongation in 1866 to De, and certainly single now. The following are all the measures —

	°	″	
Ma	P = 159·8	D = 0·37	1843·4
OΣ	340·6	0·44	1846·4

No. 310 72 *Herculis.* σ 544.

Only found in Σ's first Catalogue, and without description. All the stars properly called double were incorporated in *Mensuræ Micrometricæ*, and Σ evidently referred to some distant star. The nearest is a 10 m star in the direction of 331°·1, and this has a minute 3″ attendant in 213°·3

No. 311. Σ 2163.

The following are all the measures:—

	°	″	
Σ	P = 103·5	D = 1·51	1830·0
Se.	97·8	1·46	1858·9
De	95·0	1·5	1866·5
β	97·2	1·88	1878·3.

No. 312. Σ 2172.

Probably unchanged.

	°	″	
Σ	P = 173·1	D = 11·55	1830·8
β	170·5	11·62	1878·5.

No. 313. Σ 2175.

H. suspected a star nearer than the 10″ companion of Σ. Nothing seen on this occasion There is no change in Σ's pair.

No. 315 Σ 2190.

There seems to be an error of 10° in Σ, since the angle has remained unchanged for the last 15 years.

	°	″	
Σ	P = 33·2	D = 10·17	1829·7
Ma	33·7	10·17	1843·7
De	23·0	10·18	1863·4
Kn.	23·4	9·63	1872·4
W S	24·9	10·58	1876·5
β	23·9	10·16	1878·5

H 2807 has exactly the same R A, but 25′ south, and is described, 22°·4 : 8″± : 7 .. 11. There is no 7 m star in or near this place, and no double of this description. The observation of H undoubtedly refers to Σ 2190, and as it was made about the time of Σ's measure, it supports the theory of an error of 10° in the printed angle of the latter The observation of Ma. is on a single night, and many mistakes of this kind are found in his series

No 316 OΣ 333

A suspected close pair, and retained in the Pulkowa Catalogue of 1850, but not afterwards seen double by OΣ. De found it single in 1865, as I have on prior occasions with the 6-inch The only evidence favouring duplicity is in two doubtful measures of Ma., 154° 0″·2 ? (1845·0) There is not much doubt of this star being single

No 317 De 16. (AB = Σ 2214)

The duplicity of Σ's companion was discovered by De in 1863 There is no change in Σ's pair For the close pair we have:—

		″	
De.	P = 143·3	D = 1·5	1863·6
OΣ	154·0	1·43	1869·7
β	147·9	0·97	1878·3

No 318 *μ Herculis.* A. C. 7.

A few of the measures will indicate the rapid motion of this interesting binary —

	°	″	
DA	P = 60 4	D = 2 05	1859 7
OΣ	78 5	1·50	1862 8
OΣ	98 7	0 88	1868 5
OΣ	156 8	0 62	1871 5
OΣ	185 5	0 63	1873 5
NE	202 4	0·75	1874 5
HL	220 6	1 18	1875 7
HL	223·4	0 72	1876 6
DE	229 7	0 87	1877 5
HL	232 8	0 85	1877 6
β	234 9	1 05	1878 5

No 322. Σ 3128

The change indicated by the two sets of measures by Σ is not supported by my single observation:—

	°	″	
Σ	P = 31 4	D = 1 51	1831 4
Σ	24 0	1 52	1835 6
β	35 0	1 25	1878 3.

No. 324 H 4995

H 4995 is described, 140°± . 18″± : 6½ . . 12 ; "a third closer suspected" No third star could be seen on this occasion, which was sufficiently favourable to make the existence of any such companion very improbable.

No. 326 (AC = ♅ N. 40 = ♅ N. 6 = SH 379.)

The star B was discovered by H., having been overlooked by ♅ and SH. D was added by LANGLEY with the Harvard College Refractor, and also one of the fainter companions, probably G. The other members of the group were detected by Hn., who has thoroughly investigated the question of the apparent proper motion of the great trifid nebula which surrounds this multiple system (See *American Journal of Science*, Vol. xiv, pp 433–458.)

The following measures are by Hn. with the Washington 26-inch —

	°	″	
A and B	P = 22·7	D = 6·49	1875·6
A and C	210·7	10·75	1875·6
C and D	283·4	2·40	1875·6
C and E	192·6	5·80	1875·6
A and F	106·7	19·50	1875·6

There is no evidence of change in the old components.

No. 327. 70 *Ophiuchi.*

J suggested the existence of a third star by way of explaining some apparent irregularities in the orbital motion, and some observers have suspected an elongation of one of the components. Both stars were perfectly round with the highest powers on this occasion, as they have always been to me heretofore, and no trace of any third star near.

No. 328. 72 *Ophiuchi* (AB = OΣ 342.)

On several occasions OΣ measured a companion at a distance of about 1″·5 in *nf.* quadrant, the last observation being in 1876. Ne., on two very fine nights in 1874, saw no trace of any close star with the 26-inch, and Hl. was equally unsuccessful in 1876. I examined A several times, but found nothing. There is an excessively faint star, nearer than H.'s companion, detected by Ne. when looking for a close star. I saw it fairly, but did not measure it. Ne. gives, 292° · 26″.

No. 329. 99 *Herculis.* A. C 15.

This pair, like many others, has unfortunately been entirely neglected since the first measures by Da. shortly after its discovery in 1859. The change is very marked both in direction and distance. It is now, from the inequality of the components, a rather difficult pair. The following are all the measures —

	°	″	
Da.	P = 347·1	D = 1·71	1859·6
β	24·4	0·99	1878·5

No 330. 102 *Herculis* A. G C 8.

No other measures of this minute attendant It was detected by A G. C in 1875 with a 12-inch aperture.

No 331. μ *Sagittarii.* (AC = β 292)

The minute star between A and D of H was picked up by me with the Washington 26-inch, and is now measured for the first time. No certain indications of change in H 's nearest star —

	°	″	
Mu	P = 259 9	D = 16 08	1836 5
O S	258 4	17 10	1877 6
β	259 2	16 91	1878 4

No 332. 16 *Sagittarii.* β 286.

This also was found with the Washington 26-inch in 1874. The last measure was made so soon after sunset that no artificial illumination of the wires was necessary. The mean result is :—

	°	″	
β	P = 218 5	D = 5 67	1878 5.

No. 333. H 2827.

The description in H. is, 254° 8 15″± : 9–10 = 9–10 ; " a very remarkable object ; a double star in a pretty large, bright, oval nebula 50″ in diameter "

No 336 *Herculis* 452. Σ 2315

Some of the measures of this close binary are .—

	°	″	
Σ	P = 281·1	D = 0 59	1830 7
OΣ	257 6	0 53	1863·7
Ne	250 3	0 39	1874 6
Shp	247 0	0 38	1875 9
β	251 7	0 31	1878 4.

It appears to be slowly closing up.

No. 337 Σ 2318

The following are all the measures of this pair —

	°	″	
Σ	P = 257·1	D = 12·85	1829·7
Ma	256·8	20·03	1843·7
De.	255·7	20·66	1865·1
Hd	255·3	20·85	1866·7
β	254·9	20·81	1878·4

There seems to be a slow retrograde movement in the angle, but it is evident the distance could not have been as given by Σ if the later measures are correct. The close agreement in all the later distances makes it almost certain that there is an error of some kind in Σ I have already suggested (*Astr. Nach*, 2210) that a mistake in a single figure in transcribing or printing the distance of Σ may have occurred, and if we suppose the figures to be 19″·85, instead of 12″·85, the whole series of observations would substantially harmonise. I hope the original records will be examined to see if this is the case I have carefully looked for any other pair in this vicinity agreeing with Σ's description, and find none.

No 338. OΣ 351

The measures do not make change probable.

	°	″	
OΣ	P = 25·0	D = 0·49	1846·4
De	30·6	obl	1867·7
β	29·7	0·63	1878·4

No 339 Σ 2327

Companion not seen by De in 1864. Apparently fixed

	°	″	
Σ	P = 314·9	D = 19·27	1830·8
β	316·0	19·01	1878·4

No. 340. OΣ 355 = H 862.

This is a wide pair, the larger of which Ma. measured as a close pair, 18°·2 : 0″·25 (1843·5) Probably error in Ma., as OΣ did not regard it as a close pair

No. 341. Σ 2344.

Noted as single, or not found, by several observers (see *Astr. Nach.*, 2106); but this is undoubtedly to be attributed to mistaking for it a brighter star in the immediate vicinity which now more nearly agrees with the magnitude assigned by Σ. The principal star of Σ 2344 is only 9·3 m. in Argelander, and that is about what it appears now. There is no other measure since Σ.

	°	″	
Σ	P = 179·0	D = 1·38	1829·7
β	180·4	1·58	1878·4

No. 342. OΣ 357.

At all times a difficult pair. Some of the measures are not very accordant:—

	°	″	
OΣ	P = 275·5	D = 0·48	1845·1
OΣ	264·4	0·53	1855·7
OΣ	256·9	0·53	1872·6
β	258·9	0·52	1878·6

No. 343. *α Lyræ.*

The minute star, C, was discovered by Wn., and the measures made at that time are all I am acquainted with preceding my own. The change corresponds to the proper motion of A.—

	°	″	
Wn	P = 298·8	D = 46·87	1864·8
β	292·0	51·85	1878·4

I have examined *α Lyræ* once under very favourable conditions with the Washington 26-inch when the star was near the meridian, and many times with the 18½-inch, but have never seen the slightest trace of the close stars supposed to have been seen by Buckingham and others (*Monthly Notices*, November 1867.)

These were certainly not real stars, but optical illusions of some kind, due to the observer or the instrument. The object-glasses of Alvan Clark & Sons rarely give these spurious images in the vicinity of bright stars.

No. 344 Σ 2358.

Apparently unchanged.

	°	″	
Σ	P = 216·5	D = 2·58	1831·4
Se	219·5	2·44	1857·7
β	218·5	2·90	1878·5

No. 345. Σ 2384.

This pair is still apparently single, as found by De. in 1865. The plane of motion appears to be nearly in the line of sight:—

	°	″	
Σ	P = 307·2	D = 0·82	1832·3
Da	312·8	0·7	1841·0
OΣ	318·0	0·61	1846·3
Da	332·9	0·3±	1854·8

No. 346. Sh. 277.

A and B make the well-known "debilissima" pair between ε^1 and ε^2 *Lyræ*, with which I have connected by measures two fainter stars near by. I am not aware of any prior measures, with the exception of H., 221°·0 : 45″± : 13 = 13.

No. 347. β *Lyræ*. (AC = β 293.)

The minute star, C, noted with the Washington 26-inch, has not been measured before. The companion of Σ appears to be fixed.—

	°	″	
Σ	P = 149·8	D = 45·77	1835·2
β	149·1	45·64	1878·4.

No. 348. OΣ 364

OΣ has a single measure of a small star, 162°·8 : 0″·74 (1842·7), but he was unable to see it after that time, and is inclined to attribute the observation to some illusion.

On two occasions I failed to see any trace of duplicity

No. 349 *Lyræ* 91 OΣ 525 (AC = SH. 282)

DE called the small star 9·5 m., and OΣ, 10·3 To me it has always seemed much fainter, and was very difficult with the 6-inch. DA. says: "about the most difficult object I could measure with 7½ inches, and nearly the *min vis*" The following are the measures of AB :—

	°	″	
OΣ	P = 128·0	D = 1·55	1849·7
DA	124·5	1·86	1853·7
DE	132·8	1·36	1869·8
β	124·6	1·56	1878·4

No. 350 OΣ 365. (AC = Σ 3130)

There is no change in the 3″ companion of Σ In 1841 OΣ found the large star a close pair. In 1852 it was single, and again in 1865 It is probably a binary of short period The following are all the measures:—

	°	″	
OΣ	P = 168·1	D = 0·50	1841·6
OΣ	.	single	1852–4
OΣ	166·1	0·50	1857·7
DE		single	1865–6
β	...	single	1878·4

No. 351. γ *Lyræ* OΣ 544. A. G. C. 9

One of the recent additions to the Pulkowa numbers. It was found some years ago by A. G. C. with a 12-inch glass —

	°	″	
OΣ	P = 296·9	D = 13·79	1868·6
NE	297·8	12·48	1874·5
β	301·1	12·76	1878·4

No. 352 ζ *Sagittarii.*

This was found by WINLOCK many years ago to be a close pair with the Harvard College 15-inch, but no facts, so far as I am aware, have been published in relation to it The only measures to be found are those of Ne, in the *Washington Observations*, 1867 I have examined this star many times in the past few years with the 6-inch, and with larger apertures, but never have been able before to see it double It is certainly now about as it was in 1867, and possibly there is no change; but it seems strange that I should at all times have failed to see at least some signs of duplicity It will be observed that the angle is reversed in my measure The following star was decidedly the smallest, but the difference is not large enough to infer change from the reversal of the angle There may have been an occultation since 1867, or the low declination may explain the negative results heretofore —

	°	″	
Ne	P = 260 8	D = 0 48	1867 8
β	84 2	0 42	1878 7

There is a very distant star which makes H V. 78.

No. 353 Σ 2434.

The close pair has considerable angular motion.

	°	″	
Σ	P = 80 5	D = 1 93	1831 6
De	69 6	1 79	1864 7
O Σ	63 3	1 58	1877 7
β	64 1	1 53	1878 6

No. 354. ζ *Aquilæ* β 287

The companion was found by me in 1874 with the Washington 26-inch A fine object with a large aperture. Edgecomb sees it with a 9 4-inch Clark Refractor The only measures are the following —

	°	″	
Ne	P = 58 9	D = 5 53	1874 6
β	59 6	4 92	1878 5

No 355. AB = Σ 2462.

I have added two minute stars, all about the same distance from the primary No material change in AB.

No 358. OΣ 368.

The small star, C, does not appear to have been seen before. There is but little change, if any, in the close pair

	°	″	
OΣ	P = 217.5	D = 0.81	1850.4
De	214.5	0.94	1867.1
β	216.2	1.03	1878.7

No 360. Σ 2514.

The motion is apparently rectilinear The following are all the measures·—

	°	″	
Σ	P = 277.0	D = 7.39	1832.7
De	306.8	8.12	1866.6
β	316.3	8.51	1878.4

No. 361 Σ 2512.

The only measure since Σ, evidently fixed —

	°	″	
Σ	P = 311.8	D = 21.98	1832.5
β	310.5	22·23	1878.5

No. 362 Σ 2512

The distance has greatly diminished, probably the result of proper motion.—

	°	″	
Σ	P = 18.3	D = 18.74	1829.2
De	22.5	14.60	1865.0
β	23.8	12.98	1878.6

No 363 Σ 2636

Very decided motion, and probably binary The following are all the observations —

	°	″	
Σ	P = 35.5	D = 1.95	1831.2
Ma	37.3	1.86	1842.7
De	57.7	1.79	1865.6
β	64.5	1.76	1878.7

No. 366 54 *Sagittarii.* H. 599

In one Catalogue H called the small star 18 m No change in the larger star. No other measures of B. For C we have —

	°	″	
J	P = 42 2	D = 45 59	1845 8
β	41 7	45 57	1878 7

No. 367 Σ 2557. (AC = β 54)

The small star was added with the 6-inch There may be a small decrease in the distance of AB

	°	″	
Σ	P = 104 7	D = 11 42	1831 8
De	104 5	11 14	1867 7
β	103 4	10 76	1878 5

No 368 Σ 2564

Change is clearly shown.

	°	″	
Σ	P = 184 0	D = 10 78	1832 3
De	178 5	10 10	1866 3
β	175 1	10 04	1878 4

No 369 χ *Aquilæ.* OΣ 380.

There does not seem to be any material change in either the angle or distance, as will appear by the following.—

	°	″	
OΣ	P = 74 8	D = 0 62	1850 7
Se	76 9	0 54	1858 0
De	69 4	obl.	1867 8
Ne	77 4	0 51	1874 7
β	74 6	0 64	1877 7

OΣ measured a third star, 1″ 2 distant in 1842, but it was not seen on several later nights Ne could not find it with the 26-inch in 1874, and I saw no trace of it on any of these occasions, when the close pair was widely separated

No 370 OΣ 382.

A close and difficult pair, but thus far without sensible variation.

	°	″	
OΣ	P = 353 8	D = 0 48	1849 8
DE	173 7	obl	1866 9
NE	357 5	0 42	1874 7
β	175 3	0 45	1878 5

No 371 Σ 2574

Slow direct motion in angle and distance diminishing

	°	″	
Σ	P = 129 4	D = 0 96	1832 2
DE	141 4	0 6	1866 3
β	145 0	0 63	1878 5

No. 372 P. XIX 257 A. G C. 10. (AC = Σ 2570.)

The principal star of Σ 2570 was found by A G. C in 1875 to be a very close pair with an aperture of 12 inches. The distance cannot exceed 0″·25 I know of no other measures with which to compare my own. There is no change in Σ's companion This star is very near γ *Aquilæ*.

No 373. OΣ (App) 190.

The large stars, A and C, make one of the list of wide couples given in the first edition of the Pulkowa Catalogue The small star has not been before observed. The only measures of AB are —

	°	″	
DE.	P = 316 5	D = 67 60	1873 5
β	316 8	67 32	1878 4.

No. 374. γ *Aquilæ*.

The only earlier measure of the nearest of many stars in the field is given below It is not in any Catalogue of double stars

	°	″	
MU.	P = 270 5	D = 49 08	1837

No. 376 ζ *Sagittæ*. A. G. C 11 (AC = Σ 2585.)

The duplicity of the large star was discovered by A G C. about the same time as Σ 2570, given above, and with the same aperture There is no apparent change in the angle, but it was certainly a little wider in 1878 than the preceding year, and may become a moderately easy pair to measure in a few years The mean result of the five measures is :—

	°	″	
β	P = 157 6	D = 0 29	1878 1

There is no change in the H and Σ star.

No. 377. B A C 6814. H. 2904

The angular change was sufficient to attract my attention from inspection, and it was measured on three nights with the 6-inch in 1875. The first measure by H. is from the Catalogue in which the star first appears, and the other a subsequent measure from his Eighth Catalogue:—

	°	″	
H	P = 173 5	D = 20±	
H.	170 6	20±	1834 6
β	144 7		1875 1
O S.	141 6	18 27	1877 7
β	140·8	18 39	1878 7

No 378. β *Aquilæ* OΣ 532.

The two stars have a common proper motion and are probably physically connected:—

	°	″	
Mu	P = 23 8	D = 11 81	1838 8
OΣ	17 0	12 60	1858 1
De	17·8	11 98	1868·1
OΣ	15 6	12 67	1874 7
β	16·5	12 00	1878 6

No. 379 β 425

The small star, C, was added by De when measuring AB. The following are all the measures of the close pair:—

	°	″	
De	P = 241·3	D = 1·26	1876·3
β	240·2	1·32	1878·6

No. 380. A C. 16. (A and C = OΣ (App.) 195.)

Close pair discovered by A C. in 1858. There is not much change since that time —

	°	″	
Da	P = 234·3	D = 0·35±	1859·6
De	64·0	oval	1872·5
Ne	241·4	0·45	1874·7
β	237·7	0·45	1878·7.

No. 381. *Cygni* 116 OΣ 392. (AC = Σ 2607.)

The principal star of Σ 2607 was found by OΣ in 1841 to be double. The following are all the measures:—

	°	″	
Ma	P = 324·3	D = 0·2	1843·8
OΣ	322·0	0·44	1844·7
OΣ	317·1	0·43	1855·6
De	306·9	.	1867·4
β	317·0	0·31	1878·5

No material change in the third star, C, since Σ

No 382 χ *Sagittæ* H IV 100

H gives the following description.—

	°	″	
AB	P = 259·6	D = 23·03	1783·6
AC	280 ±	60 ±	1783·6

I have always supposed his AB to refer to two distant stars, about 23″ apart, and C to be χ itself The angles and distance then all correspond with the stars as they now appear. The star I have measured was first seen with the 6-inch, but is quite faint.

No. 385 Σ 2615.

There may be a little change in the angle, but the increase in distance as shown by the measure from the *Washington Observations*, 1867, is not confirmed by my measures.

	°	″	
Σ	P = 323.2	D = 10.82	1828.9
Ferguson	321.6	11.84	1863.7
β	318.4	10.60	1878.5.

No. 386. Σ 2619.

The small star, C, is not in Σ. It was first noted by H., and subsequently by OΣ, who found it very faint in 1851. In 1854 another small star about 6″ from C was detected. This has not been measured. I did not notice it on this occasion, although it was not looked for. Σ's pair appears to be fixed. The only measures of AC are:—

	°	″	
OΣ	P = 299.6	D = 17.33	1862.8
β	294.2	18.40	1878.4

No 387 26 *Cygni.* H V. 47

The small star, C, not before noted No measures in H of AB For comparison we have only.—

	°	″	
De	P = 146.3	D = 41.60	1873.5
β	146.8	41.76	1878.4

No 391 OΣ 400.

Undoubtedly a binary system.

	°	″	
OΣ	P = 334.9	D = 0.64	1845.7
OΣ	324.6	0.59	1853.2
De	307.8	obl	1866.7
Shp	267.9	0.3±	1875.7
β	..	single	1878.6

No 392. ∑ 2652.

If this was really single in 1863, it would tend to show a rapid binary system, and, as in 42 *Comæ*, with but little variation in the angle.

	°	″	
Σ	P = 283 2	D = 0 28	1836 5
OΣ	288 0	0 40	1845 6
Se	278 9	0 3	1857 4
De		single	1863 9
β	269 9	0 42	1878 5

No. 394 ∑ 2658 = ♅ N 72.

A decided change in both companions For A and B we have :—

	°	″	
Σ	P = 126 9	D = 5 49	1831 6
De	123 0	5 45	1863 5
β	119 9	5 21	1878 6,

and for A and C —

	°	″	
Σ	P = 216 8	D = 32 06	1832 1
De	213 2	37 80	1863 5
β	212 4	40 50	1878 6.

If the small star, C, is fixed, evidently A and B have a common proper motion

No 395 α^2 *Capricorni* A G C. 12. (AB = H 608.)

The duplicity of H.'s small companion, which in the first observation he called 16 m , was discovered by A G. C with the 18½-inch object-glass—now at the Dearborn Observatory—while it was in the possession of the makers It is a beautiful object with a sufficient aperture. The only measures are the following —

	°	″	
Hn & Ne	P = 58 1	D = 1 48	1874 6
Hl	245 2	1 14	1875 7
β	61·2	1 06	1878 5

For A and BC we have:—

	°	″	
MH	P = 144 1	D = 6 36	1846 7
β	150 2	7 41	1878 5

The measure of MH is a mean of 21 nights for distance, and 13 nights for angle

No. 396 Σ 2662.

But little, if any, change. The single observation of SE evidently has an error in the distance, perhaps 1″, or has reference to some other pair These are the measures recorded.—

	°	″	
Σ	P = 38 9	D = 1 72	1831 0
MA	39 9	2 00	1842 7
SE	41 3	0 45	1856 6
W S	41 7		1875 7
β	36 6	1 65	1878 5

No 397 *ν Capricorni.*

Not in any double star Catalogue, but noted in the *Munich Observations.* There is an error of 180° in the position angle

	°	″	
MU	P = 28 0	D = 56 33	1836
β	210 1	55 38	1877 8

No. 398. ♅ N 138.

Given in ♅ without measures as "Class I" Peters (A. N 1635) picked it up when observing an asteroid, and measured it, 331° 8 4″ 0 This is the only observation I have found. There is a small error in ♅'s place

No. 401. 1 *Delphini* β 63

My measure of this is not good. The measure given below by DE is a mean of 4 nights' observations (A N 2081), and that by NE a single night·—

	°	″	
NE	P = 350 0	D = 0 64	1874 7
DE	342 4	0 86	1875 8
β	345 0	1 22	1878 4

The minute star added with the Washington 26-inch (β 297) was not seen on this occasion

No 402 Σ 2690

There is no evidence of change either in the wide pair, Σ 2690, or the close pair discovered by Da The 16 m star added by H. is given 121° 5 20″±, and no later measures. If this single observation can be depended upon, there would seem to be some change in the angle The mean result of my measures is.—

°	″	
P = 108 4	D = 23 40	1878 2

No. 403 Ma 8.

From a short list of new pairs by Ma The following are the only measures·—

	°	″	
Ma	P = 249 3	D = 18 31	1843 8
β	248 4	19 13	1878 2

No 404. Σ 2703.

B remains fixed, but the distance of C has increased

	°	″	
Σ	P = 217 9	D = 54 38	1829 4
Du	217 4	57 03	1868 5
β	217 1	57 78	1878 7

No 405. β *Delphini.* β 151.

There can be no doubt of the binary character of the close pair. When discovered in 1873 with the 6-inch it was a comparatively easy object. It has been gradually closing up since, and it is not likely that it will be measurable after the present year (1878) until the smaller star emerges in the opposite quadrant. It is now excessively difficult, requiring the best atmospheric conditions The following are the results of the observations for each year —

	°	″		
β	P = 355 ±	D = 0 7±	1873 6	Est
De	15 6	0 65	1874 6	4 Obs
Ne	13 6	0 49	1874 7	3 ”
De	20 1	0 54	1875 6	4 ”
Shp	15 1	0 4±	1875 8	5 ”
De	25 8	0 48	1876 6	4 ”
De	29 7	0 51	1877 7	5 ”
β	40 8	0 32	1877 8	4 ”
De	59 2	obl	1878 7	1 ”
β	53 7	0 24	1878 6	4 ”

The small star, C, is not in Σ. It was noted by H with the angle 107° 7, and has not been measured since prior to my observations The change in this and in D are due to proper motion

No 406 *κ Delphini.* OΣ 533.

All the prior measures of this pair are by OΣ and De, some of which are —

	°	″	
OΣ	P = 12 4	D = 10 23	1851 6
OΣ	359 0	10 32	1859 6
De	345 7	9 41	1868 1
OΣ	335 1	10 88	1874 8
De	327·8	11 10	1877 7
β	329 2	10 59	1878 2

No. 407. *α Delphini* H 1554.

C is H 's nearest star, the angle of which he gives, 278° 0. With the Washington 26-inch I found a nearer star, but it was too difficult to measure when the more distant stars were observed.

No. 411. Σ 2720.

This is the only measure since Σ.—

	°	″	
Σ	P = 185 0	D = 3 81	1830 4
β	182 1	4 07	1878 7

No. 413. *Cephei* 55. β 152.

The following is a mean of 5 nights by De.—

	°	″	
De	P = 111·0	D = 0·44	1876·0
β	112·3	0·55	1878·5

No. 415 Σ 2734.

Change in angle and distance.

	°	″	
Σ	P = 181·7	D = 28·50	1829·8
De	187·9	26·72	1863·5
β	191·2	25·82	1878·6

No. 416. OΣ 418.

The only material change is in the distance.

	°	″	
OΣ	P = 301·8	D = 0·56	1842·7
Da	115·9	0·61	1853·8
De	292·4	1·01	1867·0
β	294·8	1·2±	1877·7

No. 417. OΣ 419.

The measures do not indicate any great change.

	°	″	
OΣ	P = 40·0	D = 1·78	1847·1
De	36·6	1·62	1866·2
β	38·0	1·65	1877·7

No. 418. OΣ 424.

Appears to be a binary system in perhaps rapid motion, as De. found it single or doubtful in 1865. The following are all the measures:—

	°	″	
OΣ	P = 332·0	D = 0·46	1845·7
OΣ	325·5	0·46	1846·7
Ma.	145·6	0·25	1848·7
OΣ	318·9	0·36	1852·6
β	327·7	0·45	1878·6.

In 1876 I noted it as being absolutely round with the highest powers on the 6-inch aperture.

No. 419. H 3006

The description in H. is, 300°± : ½″ · 10 m., "a violent suspicion, which higher powers increase." I looked for this twice with the 6-inch without success. The distance is considerably greater than suspected by H., but that under the circumstances could hardly be taken as evidence of change.

No. 420. H̥ IV. 113 = H. 613 = Σ 2748 *rej.*

The faint star, C, was detected by Mr. I. W. Ward with an aperture of only 4·3 inches. It is a very faint object. For AB we have:—

	°	″	
H̥	P = 298·4	D = 17·50	1783·7
De	299·5	18·77	1876·8
β	299·9	18·72	1878·5

De. calls AB gold and blue.

No. 421. Σ 2749

The duplicity of Σ's companion was discovered by Se. in 1856. The few measures that have been made indicate rapid motion. No change in the wide pair:—

	°	″	
Se	P = 127·6	D = 0·6	1856·6
De	141·7	0·8	1863·9
β	148·9	1·13	1877·8

No. 423. OΣ 527.

It is not easy to reconcile some of the measures, but there has been some angular motion. The following are all the measures made of this pair. The observations of Ma. are credited to OΣ 429; but that star is not double:—

	°	″	
OΣ	P = 306·2	D = 0·40	1846·8
Ma	314·4	0·45	1848·7
OΣ	295·1	0·33	1852·6
OΣ	290·6	0·46	1859·6
De	319·9	obl	1869·8
β	285·0	0·52	1878·3.

The angles of Ma. and De are increased 180° for convenience of comparison I found the *p.* star manifestly the smallest

No 424 (Nebula and Star)

This tolerably bright nebula was found with the 6-inch several years ago, and noted at the end of my third list of new double stars As suspected there, it is double, and I have measured the distance between the centres of the two parts, and also the distance from a 9 m star. There is an excessively faint star which, with the nebula and the 9 m star, makes a nearly equilateral triangle.

No. 425. OΣ 429 *rej*

This pair, at one time suspected to be double by OΣ, was rejected as single in the Catalogue of 1850, and found single later by De Ma. has two measures of it, but there is no doubt whatever that he observed OΣ 527, which is in the immediate vicinity These measures are given in the note to that star

No. 427. γ *Equulei.* Kn. 2.

The close star was discovered by Kn. in 1867.

	°	″	
Kn	P = 276 8	D = 2 13	1867 5
β	274 5	2 16	1877 7.

The faint star, first noted with the 6-inch, has not been measured before.

No. 429. δ *Equulei* OΣ 535

One of the closest pairs, and thought by OΣ to be a binary of very short period. My single angle does not agree very well with the measures of OΣ, the most of the angles being about 200° The following are the principal observations of OΣ. All other observers have measured only the wide pair (Σ 2777) —

°	″	
P = 191 9	D = 0 27	1853 9
...	single	1854–6
209 5	0 21	1857 7
236 ?	...	1861 6
24 0	elongated	1874 6
1 8	wedged	1874 7
221·2	0 33±	1874 7

No. 430 *τ Cygni* A. G C. 13.

Discovered in 1874 by A. G. C with the Washington 26-inch. There is an excessively faint star for which HL. gives, 260°·3 : 15″ 68 (1876 9). I could see this, but did not attempt measures. The close pair is in rapid movement, as will be seen from the following:—

	°	″	
DE	P = 174 5	D = 1 24	1875 1
DE	170 5	1 32	1875 7
DE	161 5	1 24	1876 8
HL	160 2	1 04	1876 9
DE	155 3	1 26	1877 7
β	150 0	1 06	1878 4

No 431 *ν Cygni* OΣ 433 = H. 932

No evidence of change

		°	″	
A and B	OΣ	P = 220 1	D = 15 07	1849 5
	DE	219 9	15 06	1866 7
	β	218 5	14 77	1878 4
A and C	OΣ	177 5	21 20	1849 5
	DE	178 5	21 28	1866 7
	β	177 9	21 38	1878 4

No. 432. β 289.

This triple was found by me with the Washington 26-inch in 1874. It is in a low power field with the preceding star, *ν Cygni.* I know of no other measures of it.

No 433. OΣ 435.

Very little angular motion.

	°	″	
OΣ	P = 23 8	D = 0 60	1848 1
DA	201 8	0 5±	1852 4
DE	196 2	obl.	1866 0
β	205·9	0 62	1878 7

No. 434. β *Equulei* H 3023.

I have added the nearest star, B, which is much fainter than any of the H companions H. gives the angles of C, D, and E, respectively, 314°·4, 14° 5, and 278° 0

No. 435. 18 *Aquarii.* H 5517.

H. notes, "a most minute point strongly suspected," 270° : 13″. I have examined this star many times, with my 6-inch, and the 9 4-inch of the Dartmouth College Observatory, prior to the present observation, but no suspicion at any time of any near companion, and I am confident nothing answering the description of H. exists. The nearest I could find I have measured.

No. 437. β 164. (AC = Σ 2793.)

The following are all the measures of the close pair:—

	°	″	
Ne	P = 244 8	D = 0 64	1874 7
De	241 3	0 56	1875 1
β	237 3	0 82	1877 7

No. 438. β 72.

Near β *Aquarii*, and in the field with β 684.

	°	″	
De	P = 45 2	D = 1 82	1877 1
β	43 1	1 89	1878 1.

No. 439. β *Aquarii* ♅ V. 76 = H. 936.

H. gives the angle 322·8. The third star, C, was noted with the 6-inch.

No. 445. H. 947 = ♅ N. 74.

The only other measures are:—

	°	″	
P Sm.	P = 92 5	D = 20 32	1862 7
	323 6	21 74	1862 7

No. 448. H. 3069. (AB = OΣ 453.)

H. did not detect the close pair, and OΣ has no observation of C. The description in H. is, 82°·9 : 25″±. The measures of OΣ and De. show no change in AB.

No. 449 OΣ 537.

One of the later additions to the Pulkowa list. OΣ has but one observation, the angle of which is 180° in error. At times I have found this very difficult with the 6-inch, and once or twice it was not seen at all. There seems to have been some change in the angle and distance since 1856. I know of no other measures:—

	°	″	
OΣ	P = 13·5	D = 2·57	1856·7
β	201·5	2·16	1878·6

No. 450. OΣ 458.

In the field with the preceding pair. The minute star has not been observed before. I first noted it with the 9·4-inch of the Dartmouth College Observatory. There is no material change in the close pair:—

	°	″	
OΣ	P = 348·8	D = 0·71	1851·7
De.	353·7	0·80	1866·9
β	351·9	0·86	1878·6

No. 451. AC = H. 5524.

B was discovered by Howe at Cincinnati, and measured, 270°·3 : 9″·09 (1877·8). H. has no measures of AC.

No 454 Σ 2860

Very decided motion, apparently rectilinear.

	°	″	
Σ	P = 250·8	D = 3·32	1832·3
Ma.	252·4	4·45	1844·4
De	254·6	5·15	1864·9
β	255·6	5·96	1878·5.

No. 455. OΣ 460.

The only measures of AB are:—

	°	″	
OΣ	P = 352 2	D = 5 78	1849·7
β	351 8	6 71	1877 8.

For AC we have:—

	°	″	
OΣ	P = 49 1	D = 15 95	1849 7
De.	46 7	15 77	1866·5
β	46 3	16 04	1877 8.

No. 457. OΣ 462.

Close pair appears to be without change. The small star has been measured before only by OΣ:—

	°	″	
OΣ	P = 33 8	D = 7 53	1850 0
β	31 0	6 95	1877 8.

No. 458. π^1 *Pegasi.*

The distant, C, is in Sm. I have measured also a smaller and nearer companion.

No. 459. *Pegasi* 129. Σ 2869.

The following are all the measures:—

	°	″	
Σ	P = 253 7	D = 22 74	1829 5
De	252·9	21 09	1864 7
β	253 4	21 53	1878·4

No. 460. Σ 2879.

Probably unchanged. Se. has one observation which evidently belongs to some other pair:—

	°	″	
Σ	P = 226 2	D = 0 79	1836·3
OΣ	228 8	0 85	1845 0
β	228 3	0 91	1878 7

No. 462. β 378.

AB was discovered with the 6-inch, and in measuring that pair a third star was added.

No. 463. 30 *Pegasi.* H. 962.

A fine object with a large aperture. H. measured only the angle of C, 212°·0. The only measures since are:—

		°	″	
A and B	Ds.	P = 19·8	D = 6·18	1867·1
	Ht.	19·0	6·30	1875·8
	β	18·6	6·22	1878·6
A and C	Ht.	220·7	9·80	1875·8
	β	223·0	10·04	1878·6

No. 464. 7 *Aquarii.* H. 3106.

The only measures are:—

	°	″	
Mt	P = 125·9	D = 49·46	1838·8
β	129·6	43·87	1878·7

No. 465. 51 *Aquarii.* β 172.

The measure of Ds. is the mean result of 6 nights:—

	°	″	
Ds.	P = 21·9	D = 0·44	1875·7
β	24·9	0·58	1878·2

No. 466. 34 *Pegasi.* β 290.

Discovered at Washington in 1874. The only measures for comparison are:—

	°	″	
Ht	P = 223·3	D = 2·61	1875·7
β	218·6	2·62	1877·9

No. 467. β 291.

A difficult pair within the triangle formed by 34, 35, and 37 *Pegasi.*

	°	″	
Ds	P = 157·8	D = 0·32	1875·8
β	160·0	0·42	1878·6

No 469. OΣ 471 *rej*

Rejected as single by OΣ and so found by De. in 1866 Ma. has a measure, 6° 8 : 0″ 22 (1843 6), but there is very little probability of this star being really double

No 47. 37 *Pegasi.* Σ 2912.

Binary, and now a very difficult pair. At the time of finding 34 *Pegasi* double with the Washington 26-inch, I could see no trace of duplicity in this star, and it was always single with the 6-inch. A few of the measures are:—

	°	″	
Σ	P = 115 6	D = 1 15	1835 6
Se.	117 6	0 74	1857 1
W S	122 3		1871 9
β	130 0	0 32	1878 6

From the measures it would appear that it could not have been really single in 1874.

No. 471. Σ 2915.

A decided change in the angle.

	°	″	
Σ	P = 169 0	D = 12 27	1827 8
De	158 8	12 20	1863 7
β	155 1	12 29	1877 8

No. 473 *Aquarii* 215. Σ 2936

No other late measures

	°	″	
Σ	P = 47 1	D = 4 69	1832 2
β	50 8	4 92	1877 8

No. 475. OΣ 477.

The change is probably due to proper motion.

	°	″	
OΣ	P = 122 7	D = 9 60	1846 1
De.	138 5	6 49	1867 1
OΣ	148 2	5 54	1875 7
β	154 1	4 62	1878 6.

No. 476 B.A.C 7931. (AB = H. 1802 = Σ 2942 = OΣ 478) (AC = β 450)

The third star was found last year with this instrument. No material change in AB. The third star is quite a minute point

No. 477. ξ *Pegasi*. H. 301.

There seems to be no doubt of angular motion.

	°	″	
H	P = 122 8	D = 15±	1830
De	117 7	12 17	1866 8
β	111 9	11 93	1878 6.

No. 479. H. 3152

The description in H. is, 135°4 3″± :9 . . 15. "A very difficult object, measured with 320, which still left a suspicion of illusion, though I have hardly a doubt." I have looked for this many times, but without seeing the least trace of any companion.

No. 480. Σ 2954

The following are all the measures :—

	°	″	
Σ	P = 28 6	D = 36 73	1830 9
De.	27 0	37 94	1864 9
β	27 4	37 97	1877 8

No. 481. β 383

A and C discovered with the 6-inch, and B added with the large aperture

No. 482 Σ 2959 = ♅ N. 15.

Evidently moving

	°	″	
Σ	P = 96 7	D = 15 66	1832 1
De.	101 7	14 21	1864 8
O S.	101 5	14 14	1877 8
β	102 2	13 77	1877 8

The third star, C, is new.

No 483 B.A.C. 8001. OΣ 536.

The following are all the measures of this pair :—

	°	″	
OΣ	P = 344·	D = 0·33	1852 7
OΣ	332 8	0 40	1852 7
OΣ	343 7	0 46	1853 9
OΣ	.	single	1859 6
OΣ	260 ?		1861 7
β	,	round	1874 8
β	161 5	0 47	1877 8

No. 485. Σ 2976.

A and B relatively fixed, but rectilinear motion in C

	°	″	
Σ	P = 177 7	D = 15 88	1828 4
Se	183 2	16 31	1857 4
W S	187 0	16 5	1873 8
β	188 3	16 65	1878 2

No. 486. Σ 2980.

The only measures are as follows :—

	°	″	
Σ	P = 107 9	D = 4 15	1831 1
O S	108 3	4 26	1877 9
β	111 8	4 38	1877 7.

Probably without change.

No 490. *Aquarii* 286. β 181.

The close pair has been carefully observed by De. on 4 nights with the following result :—

	°	″	
De	P = 309 2	D = 1 51	1876 3

No. 491. ψ^1 *Aquarii.*

I have only measured two minute stars not in Σ

No. 492. β 80.

De. has measured this on 4 nights, the mean result of which is given below. My angle is undoubtedly too large.

	°	″	
De	P = 300·4	D = 1·07	1875·8
β	306·1	1·24	1877·8

No. 493. 96 *Aquarii*. H 5394.

Probably fixed.

	°	″	
H.	P = 26·3	D = 10±	1836·7
De	23·5	9·88	1869·8
β	23·1	10·08	1878·6

No. 496. 78 *Pegasi*. A. G. C. 14.

Discovered in 1875 by A. G. C. with a 12-inch aperture. De., by 4 measures, gives the following result:—

	°	″	
De.	P = 192·0	D = 1·45	1876·6
β	191·8	1·61	1878·8.

No. 498. OΣ 506 *rej.*

This was observed on account of the variation in distance shown by a single measure of Ma. My observations do not confirm such change:—

	°	″	
Ma	P = 80·5	D = 16·67	1843·9
De	79·9	17·93	1867·5
β	79·4	18·09	1877·8

No. 501. β 281. (AC = H. 998.)

The close star was discovered by me with the 9·4-inch of the Dartmouth College Observatory. It has not been measured by De., and H. has no measures of C.

No. 502. Σ 3055.

The components are evidently relatively fixed.

	°	″	
Σ	P = 359·9	D = 5·67	1836·1
β	359·6	5·79	1878·6

Note.

I ascertained, too late to make the correction in its proper place, that No. 562 of the list of new stars is identical with one of the close pairs of the Pulkowa Catalogue, OΣ 122. I have made a measure, which is given below with all the prior measures on record:—

	°	″	
Ma	P = 117·8	D = 0·22	1843·2
OΣ	108·9	0·36	1847·7
Ma.	138·9	0·2	1852·3
β	117·7	0·29	1878·8

The observations furnish very little evidence of motion.

I have made another and successful search for Σ 1058, and made two measures as follows:—

°	″			
P = 281·0	D = 22·84	1879·184	Mags 8	11
281·0	22·32	1879·200	8·5	11.

The principal star is Arg. (9°) 1497, and the place for 1880 is·—R A $7^h\ 10^m\ 17^s$, Decl 9° 37′, agreeing almost exactly with *Mensuræ Micrometricæ* It is not found in Weisse or Lalande. In Argelander it is called 7–8 magnitude. It will be interesting to watch this pair, and see whether one of the components is variable. I had supposed my search in 1878 was a thorough one. In all similar cases heretofore the explanation has been found in errors of observers, and not in the disappearance, or change, in the stars themselves

V. *Les longueurs du pendule à secondes à Poulkova, à St.-Pétersbourg, et aux différents points de la Russie occidentale, corrigées de l'influence produite par la flexion des supports du pendule construits par M. Repsold.* Par M. A. Savitsch, Professeur d'Astronomie à l'Université de St.-Pétersbourg.

◆

Dans le Mémoire présenté en 1872 à la Société Royale Astronomique de Londres, nous avons rapporté les résultats de nos recherches sur l'intensité de la pesanteur dans les onze points voisins du méridien qui s'étend de Finlande jusqu'aux bords du Danube près d'Ismail. C'était une heureuse circonstance pour la liaison de nos résultats à ceux qu'on a obtenus dans les autres endroits, que les deux pendules à réversion et leurs supports construits par M. Repsold, employés par nous en Russie, furent expédiés en Angleterre, et de là aux Indes, pour servir au même usage dans ces contrées. Les expériences faites aux Indes ont parfaitement réussi, et quand elles étaient terminées, les instruments furent renvoyés en Angleterre, et puis en Russie. Ils ont été soigneusement vérifiés à Kew, et ont servi à un habile observateur, M. le Capitaine Heaviside, à une nouvelle détermination de la longueur du pendule à secondes à Kew.

Le Directeur de l'Observatoire de Poulkova, M. O. Struve, engagea M. le Colonel Zinghere, attaché comme Astronome à cet Observatoire, à faire à l'aide de ces mêmes instruments toutes les expériences et les recherches nécessaires pour fixer la longueur du pendule à secondes à Poulkova aussi exactement que possible. C'est ce que M. Zinghere a rempli avec succès, comme on peut en juger d'après son mémoire publié en langue russe par l'Académie Impériale de St.-Pétersbourg en 1877.

Ayant trouvé les instruments dans un état aussi satisfaisant qu'ils l'étaient à Kew, l'auteur du mémoire chercha par beaucoup d'expériences les durées d'oscillations de deux pendules, le bout inférieur de chaque pendule étant lourd et l'autre bout étant léger. C'est ce qu'il a obtenu en observant les instants des coincidences du pendule employé et du pendule d'une horloge qu'il comparait, au moyen d'un chronomètre, au commencement et à la fin de chaque série d'expériences, à l'horloge, dont la marche diurne a été exactement vérifiée par les observations astronomiques. Les coincidences se succédaient dans des intervalles d'à peu près 4 minutes de temps, et chaque série d'expériences en contenait sept, les instants des trois premières et des trois dernières coincidences furent notés, celle du milieu fut omise. Deux minutes de temps avant et après chaque coincidence on inscrivait les amplitudes angulaires d'oscillations du pendule, et les températures d'après trois thermomètres vérifiés, dont l'un était placé près du bout inférieur du pendule, le second vers le milieu et le troisième vers le bout supérieur. L'état du baromètre s'inscrivait au commencement et à la fin de chaque série d'expériences, relative à la position déterminée d'un des deux couteaux servant d'axe de rotation.

Les réductions des durées d'oscillations à la durée correspondant aux amplitudes infiniment petites sont faites dans l'hypothèse que les amplitudes diminuent en progression géométrique, quand le nombre d'oscillations s'augmente en progression arithmétique,—supposition admise par tous les physiciens. Ainsi désignant par e la base des logarithmes naturels, par θ_o l'amplitude observée au milieu d'une série d'expériences, par θ_i l'amplitude correspondant à la i^{me} oscillation comptée depuis l'instant de ce milieu, et par k un coefficient dont la valeur numérique se trouve par les expériences, on a

$$\theta_i = \theta_o \, e^{-ki},$$

ou, en logarithmes ordinaires,

$$\log \theta_i = \log \theta_o - ki \log e$$

En substituant pour θ_i et i leurs valeurs relatives à chacune des sept amplitudes observées, on forme les sept équations de condition, et en les résolvant par la méthode des moindres carrés, on obtient $\log \theta_o$ et k. Il s'entend de soi-même qu'aux amplitudes immédiatement observées doivent être préalablement appliquées les corrections qui dépendent de ce que l'arc gradué, indiquant les amplitudes des oscillations, n'est pas à la même distance de l'objectif de la lunette, qui sert à faire voir le bout inférieur du pendule, que ne l'est le plan d'oscillation du pendule.

Soit τ la durée moyenne des oscillations appartenant à une série d'expériences ; ν le nombre d'oscillations entre deux coincidences consécutives ; τ' la durée d'une oscillation dont l'amplitude est infiniment petite ; si nous supposons que les amplitudes sont exprimées en minutes angulaires, on aura, d'après le système d'expériences mentionné,

$$\tau_1 = \tau - \frac{\tau \sin^2 1'}{3\ 4\ 16} \left\{ \int_{-3\nu}^{+3\nu} \theta_i^2 di + \int_{-2\nu}^{+2\nu} \theta_i^2 di + \int_{-\nu}^{+\nu} \theta_i^2 di \right\}.$$

Remplaçant θ_i par $\theta_o e^{-ki}$, on trouve

$$\int_{-s\nu}^{s\nu} \theta_o^2 e^{-2ki} dt = \theta_o^2 \left(\frac{e^{2sk\nu} - e^{-2sk\nu}}{2k} \right) = 2sk\nu\theta_o^2 \left(1 + \frac{2}{3} s^2 k^2 \nu^2 + \ldots \right),$$

comme $k\nu$ est toujours très-petit et s est égal à 3, ou à 2, ou à 1, on peut négliger dans le développement de la série les puissances de $sk\nu$ superiéures à la seconde. De cette manière M. Zinghere admet pour les réductions des durées d'oscillations à l'amplitude infiniment petite l'équation

$$\tau_1 = \tau - \frac{\tau}{16} \sin^2 1' . \theta_1^2 (1 + 4k^2\nu^2)$$

Le degré d'approximation n'est pas sensiblement supérieur à ce que nous avons obtenu dans notre mémoire de 1872.

Toutes les autres corrections furent calculées d'après les règles connues et généralement adoptées, qui sont rapportées dans notre mémoire.

Au moyen d'un appareil que nous avons mentionné dans ce mémoire, furent déterminées, avec beaucoup de soin, les distances du centre de gravité du pendule aux tranchants des couteaux, dont l'un se trouve près du bout lourd et l'autre près du bout léger du pendule.

Pour obtenir les dilatations des pendules par la chaleur, M. Zinghere mesura, dans les températures différant l'une de l'autre d'à peu près 17° ou 20° du thermomètre centigrade, les distances de deux tranchants des couteaux dans chaque pendule au moyen de l'étalon du comparateur construit par M. Repsold, et ensuite il compara dans les températures aussi différentes ce même étalon à un étalon normal vérifié par l'ancien Directeur de l'Observatoire de Poulkova, W. Struve, et dont la dilatation par la chaleur fut déterminée par cet illustre astronome. Les coefficients de la dilatation obtenus par M. Zinghere sont

0·0001897 pour le pendule No. 1,
0·0001876 „ No. 2

Nous avons cherché ces coefficients en observant les durées d'oscillations de chaque pendule dans les températures différant entre elles d'à peu près 20° centigrades; nos expériences faites en hiver 1866 donnent les coefficients

0·0001964 pour le pendule No. 1,
0·0001940 „ No. 2.

En terme moyen M. Zinghere admet 0·0001930 comme le coefficient de la dilatation pour le pendule No. 1, et 0·0001908 pour le pendule No. 2

Quant à l'élimination de l'erreur qui pourrait provenir de la différence entre les figures de l'un et l'autre couteau de chaque pendule, M. Zinghere profita des expériences aussi complètes que précises, faites à l'aide des mêmes instruments par M. le Capitaine Heaviside à Kew; il en résulte la correction de la longueur du pendule à secondes égale à −0·000363 pour le pendule No. 1, et la correction +0·000104 de la ligne de Paris pour le pendule No. 2. Une autre correction bien plus sensible est celle qui est relative à ce que les 248 lignes, indiquées par l'étalon du comparateur construit par M. Repsold, ne représentent pas exactement les 248 lignes de Paris. Les comparaisons de cet étalon aux étalons normaux qui se conservent à Poulkova donnent les corrections suivantes, pour exprimer les 251 lignes de l'étalon de M. Repsold en lignes de Paris, ou de la toise de Fortin à +13° de Réaumur

Température en grades centig.	D'après les comparaisons		Correction moyenne
	de M. Zinghere en 1875.	de M. Smislof en 1868	
+15·0	−0·0129	−0·0116	−0·0122
17·5	−0·0017	−0·0002	−0·0009
20·0	+0·0095	+0·0112	+0·0104

On a ainsi la correction +0·0013 de la ligne, qu'il faut ajouter à la distance entre les deux couteaux de chaque pendule pour exprimer cette distance en lignes de Paris à la temperature de + 18° centigrades.

La hauteur du lieu d'observation est 247·6 pieds anglais au-dessus du niveau de la mer; la latitude boréale de ce lieu est 59° 46′ 19″.

Ayant réuni tous ces éléments du calcul, M. ZINGHERE trouve, par les méthodes connues, qu'à Poulkova la longueur du pendule simple à secondes sexagésimales du temps moyen, par oscillations infiniment petites, réduites au vide et au niveau de la mer, est

440·9428 lignes de Paris:

ce sont les lignes de la toise normale de Fortin à + 13° RÉAUMUR de la température.

D'après les expériences de M. HEAVISIDE, la longueur du pendule à secondes à Kew, exprimée en lignes de l'étalon du comparateur construit par M. REPSOLD à la temperature de + 13°·1 centigrades, est 440·6775; en appliquant la correction —0·0370 pour la réduction aux mêmes lignes de Paris, on a la longueur du pendule à secondes à Kew, sous la latitude 51° 28′ 6″,

440·6405 lignes de Paris.

La théorie de la pesanteur et les nombreuses observations du pendule en différentes contrées nous permettent de représenter la longueur Λ du pendule à secondes sous la latitude géographique ϕ par la formule

$$\Lambda = 439{\cdot}3200 + 2{\cdot}2570 \sin^2\phi, \text{ lignes de Paris.}$$

Ainsi la différence $\Delta\Lambda$ des longueurs du pendule à secondes, correspondantes aux latitudes ϕ et ϕ', est

$$\Delta l = 2{\cdot}2570 \sin(\phi+\phi') \sin(\phi-\phi').$$

Pour Poulkova et Kew cette différence théorique est 0·3038 de la ligne de Paris; les expériences directes donnent 0·3023; l'accord est donc satisfaisant, et prouve qu'il n'y a pas d'anomalies sensibles dans l'intensité de la pesanteur terrestre en ces deux stations.

Dans notre mémoire présenté en 1872 à la Société Astronomique de Londres, nous avons rapporté de quelle manière nous avons déterminé la longueur du pendule à secondes à St.-Pétersbourg à l'aide des mêmes instruments qui ont été employés à Kew et à Poulkova. Les durées d'oscillations et les distances entre les tranchants des deux couteaux de chaque pendule furent obtenues relativement à chacun des deux axes de rotation, tant avant qu'après la transposition des couteaux. L'étalon du comparateur construit par M. REPSOLD a aussi été vérifié par ses comparaisons en différentes températures à l'étalon fait à Londres et examiné par M BAILY quant à sa précision et à sa dilatation par la chaleur. Nous avons trouvé qu'à St-Pétersbourg, sous la latitude de 59° 56′ 30″, la longueur du pendule à secondes est

440·9488 lignes de Paris

D'après la théorie de la pesanteur, cette longueur doit surpasser celle qui appartient à Poulkova de 0·0060 de la ligne de Paris; ce qui s'accorde parfaitement avec les résultats des expériences faites à Poulkova par M. ZINGHERE

Malgré cet accord, notre détermination restait toujours défective, en ce qu'elle donne la longueur du pendule à secondes plus courte d'à peu près 0·08 de la ligne de Paris de ce qu'elle devrait être d'après la théorie de la pesanteur et les expériences de BESSEL, de BIOT, de KATER, et des autres illustres savants. La même anomalie se manifesta dans les résultats obtenus en Allemagne au moyen des instruments semblables à ceux que nous avons employés

La cause de cette anomalie fut expliquée par M.M. PEIRCE et CELLERIER: elle dépend de la flexibilité des supports du pendule, tels qu'ils ont été construits par M. REPSOLD. Le couteau, ou l'axe de rotation de ce pendule, s'appuie à un plan horizontal formant la superficie d'une pièce d'acier fixé à un trépied, dont les branches sont de longs tubes en laiton. Deux de ces tubes se trouvent dans un plan parallèle au plan d'oscillation du pendule, et le troisième est dans un plan perpendiculaire à ce dernier. La pression qu'exerce le poids du pendule tend à produire la flexion des supports, et quand le pendule oscille autour de son axe de rotation, la composante horizontale de la pression amène une plus grande flexion, tantôt de l'un, et tantôt de l'autre tube parallèle au plan d'oscillation. Il en dérive un petit mouvement dans les supports qui modifie les oscillations du pendule et change leurs durées; il est alors impossible d'obtenir la longueur du pendule simple sans égard à ce mouvement des supports Soit l la distance réciproque des deux axes de rotation du pendule à réversion, L la longueur véritable du pendule à secondes, L′ la valeur que l'on trouve au lieu de L si l'on néglige les mouvements des supports, p le poids du pendule à réversion, et k' un coefficient qu'on détermine par les expériences destinées à la recherche de la flexibilité et des mouvements des supports: la valeur numérique de k' dépend des unités admises pour exprimer l et p. D'après la théorie donnée par M. Peirce on a

$$L = L' + k' \, p \, \frac{L'}{l}.$$

La correction $k' \, p \, \frac{L'}{l}$ est toujours positive, de sorte qu'en négligeant les mouvements des supports on obtient une longueur du pendule à secondes plus courte qu'elle ne l'est réellement; c'est ce qui arriva à tous ceux qui ont fait usage du trépied construit par M Repsold. La recherche du coefficient k' est une des plus délicates et des plus laborieuses; il fallait avoir toutes les ressources et toute l'habilité que possédait M. Plantamour pour amener cette recherche à une bonne fin. On peut voir en détail par quels moyens cet excellent observateur est parvenu à trouver le coefficient k', dans son mémoire, publié sous le titre *Recherches expérimentales sur le mouvement simultané d'un pendule et de ses supports*, par E. Plantamour, Professeur, Genève, 1878.

Pour son instrument, M. Plantamour obtient la correction 0·1724 de millimètre, ou 0·0765 de la ligne de Paris, qu'il faut ajouter à la longueur du pendule à secondes calculée en négligeant la flexibilité des supports, pour avoir la vraie longueur

Nos instruments et leurs trépieds sont tout-à-fait semblables à ceux qu'avait employés M. Plantamour, leurs formes, leurs dimensions et poids, ainsi que les métaux dont ils sont construits, sont presque les mêmes; il est donc très-probable qu'à peu près la même correction doit être appliquée aux résultats obtenus à l'aide de ces instruments sans égard au mouvement simultané du pendule et de ses supports. La correction pour un lieu particulier est proportionnelle à la longueur du pendule à secondes en ce lieu, la distance entre les deux axes de rotation restant la même. Cette longueur à St.-Pétersbourg surpasse de 0·515 de la ligne de Paris celle qui correspond à Genève; la correction à Genève étant +0·0765, on a pour St.-Pétersbourg et Poulkova la correction +0·07659, ou à peu près +0·0766 ; pour Kew la correction est +0 07654 de la ligne de Paris. En ces trois stations la flexibilité des supports du pendule n'ayant pas été prise en considération, nous ferons usage des corrections mentionnées, et ainsi nous trouvons les longueurs véritables du pendule à secondes

à St -Pétersbourg	441·0254	lignes de Paris
à Poulkova	441 0194	„
à Kew	440 7170	„

L'accord de ces valeurs avec celles qui se déduisent par la théorie de la pesanteur des expériences faites par les plus habiles physiciens en diverses contrées à l'aide d'instruments bien différents des nôtres, est une preuve de la justesse des corrections admises

Grâce aux recherches de MM. Peirce, Cellerier, et Plantamour, nous pouvons à présent donner les longueurs du pendule à secondes dans différents points de la Russie occidentale avec plus de précision que nous n'avions pu le faire dans notre mémoire présenté en 1872 à la Société Astronomique de Londres

Station	Latitude boréale			Longitude à l'est de Greenwich			Longueurs du pendule à secondes en lignes de Paris
	°	′	″	h	m	s	
Tornéa	65	50	43	1	36	54	441 2460
Nicolaistadt	63	5	33	1	26	26	441 1228
St -Pétersbourg	59	56	30	2	1	14	441 0254
Reval	59	26	37	1	39	1	441 0125
Dorpat	58	22	47	1	46	54	440 9697
Jacobstadt	56	30	3	1	43	4	440 8835
Vilna	54	41	2	1	41	12	440 8288
Belin	52	2	22	1	40	52	440 7202
Krementz	50	6	8	1	42	54	440 6467
Kamenetz-Podolsk	48	4	39	1	46	18	440 5778
Kischenev	47	1	30	1	55	18	440 5212
Ismail	45	20	34	1	55	16	440 4413

Le pendule à réversion et son trépied construit par M. Repsold sont très-commodes pour le transport et la recherche des différences entre les longueurs du pendule à secondes en diverses contrées; mais pour obtenir cette longueur à un lieu particulier, on est obligé de faire une série d'expériences difficiles à exécuter avec précision. Il serait peut-être plus commode de suspendre en un lieu unique le pendule tant à son trépied actuel, qu'à un support solide fixé à un mur, à la manière comme le faisaient avec succès le Capitaine KATER et les autres observateurs anglais. Les expériences faites pour déterminer les durées d'oscillations dans ces deux manières de suspendre le pendule seront suffisantes pour trouver la correction qui dépend de la flexibilité du trépied.

Le 16 *Janvier* 1879

A LIST OF PERSONS

TO WHOM

THE MEDALS OR TESTIMONIALS OF THE SOCIETY

HAVE BEEN ADJUDGED.

1823

June 13. CHARLES BABBAGE, Esq

The Gold Medal —For his Invention of an Engine for computing and printing Mathematical Tables

Professor JOHANN FRIEDRICH ENCKE.

The Gold Medal —For his Investigations relative to the Comet which bears his name.

CHARLES RUMKER, Esq

The Silver Medal -- For his Rediscovery of ENCKE's Comet in 1822.

M JEAN LOUIS PONS

The Silver Medal —For his Discovery of Two Comets in 1822.

1826

Feb 7 J F. W HERSCHEL, Esq , and JAMES SOUTH, Esq.

The Gold Medal, each.—For their important Researches on the subject of Multiple Stars.

Feb 10. Professor STRUVE

The Gold Medal —For his important Researches on the subject of Multiple Stars

1827

Feb 2 FRANCIS BAILY, Esq

The Gold Medal —For his "New Tables for determining the places of 2,881 Stars"

WILLIAM SAMUEL STRATFORD, Esq.

The Silver Medal —For his Superintendence of the Computation of "New Tables for determining the places of 2,881 Stars"

Feb 5 Colonel MARK BEAUFOY

The Silver Medal --For his valuable Collection of Observations, particularly those of the Eclipses of *Jupiter's* Satellites

1828
Jan. 11 Sir THOMAS MACDOUGALL BRISBANE, K.C.B.

The Gold Medal.—For his Establishment of an Observatory, and for an important series of Observations made at Paramatta.

JAMES DUNLOP, Esq.

The Gold Medal.—For his Observations of the Nebulæ of the Southern Hemisphere.

Feb. 4. Miss CAROLINE HERSCHEL

The Gold Medal.—For her recent reduction, to January 1800, of the Nebulæ discovered by Sir WILLIAM HERSCHEL.

1829
Jan. 9 Rev. WILLIAM PEARSON.

The Gold Medal—For his work entitled "An Introduction to Practical Astronomy."

Professor BESSEL.

The Gold Medal.—For his Zone Observations.

Professor SCHUMACHER

The Gold Medal.—For the Publication of his various Astronomical Tables, and the "Astronomische Nachrichten."

1830.
Jan. 8. Mr. WILLIAM RICHARDSON.

The Gold Medal.—For his Investigation of the Constant of Aberration

Professor ENCKE.

The Gold Medal.—For the New Berlin Ephemeris.

1831
Jan 14. Captain KATER.

The Gold Medal.—For his Invention of the Vertical Floating Collimator.

Baron DAMOISEAU.

The Gold Medal.—For his Memoir upon the Theory of the Moon, and for his Lunar Tables.

1833
Jan 11. Professor AIRY.

The Gold Medal.—For his Discovery of the long Inequality of *Venus* and the Earth.

1835
Jan 9 Lieutenant JOHNSON.

The Gold Medal.—For his Catalogue of 606 Southern Stars.

1836
Jan 8. Sir JOHN F. W. HERSCHEL.

The Gold Medal.—For his Catalogue of Nebulæ, printed in the "Philosophical Transactions" for 1833.

1837
Jan 13. Professor Rosenberger.
The Gold Medal.—For his Investigations relative to Halley's Comet

1839
Jan. 11. Hon John Wrottesley.
The Gold Medal.—For his Catalogue of the Right Ascensions of 1,318 Stars.

1840
Jan 10 M. Jean Plana
The Gold Medal.—For his Work, entitled "Théorie du Mouvement de la Lune."

1841
Jan. 8 Professor Bessel.
The Gold Medal.—For his Observations and Researches on the Parallax of 61 *Cygni*

1842
Jan. 14. M. Hansen.
The Gold Medal.—For his Researches in Physical Astronomy.

1843
Jan 13. Francis Baily, Esq.
The Gold Medal.—For his Experiments to determine the Mean Density of the Earth in repetition of what is generally termed the "Cavendish Experiment."

1845
Jan 10 Captain William Henry Smyth, R.N.
The Gold Medal —For his "Bedford Catalogue," forming the second part of his work entitled "Celestial Cycle"

1846
Jan. 9. George Biddell Airy, Esq., Astronomer Royal.
The Gold Medal —For his Reduction of the Observations of Planets made at the Royal Observatory, Greenwich, from 1750 to 1830.

1848
Jan. 14 *Testimonials were awarded to*

George Biddell Airy, Esq., Astronomer Royal.
For the Lunar Reductions recently made at Greenwich.

John Couch Adams, Esq.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Professor Argelander.
For his Catalogue of Stars.

1848
Jan. 14 George Bishop, Esq.
For the Foundation of an Observatory leading to various Astronomical Discoveries

Lieut.-Col George Everest.
For his Measurement of the Indian Arc.

Sir John F. W. Herschel.
For his Work on the Southern Hemisphere.

Professor P. A. Hansen.
For his Lunar Theory and Computation of Perturbations.

M. Hencke.
For his Discovery of two Planets, *Astræa* and *Hebe*.

John Russell Hind, Esq.
For his Discovery of Two Planets, *Iris* and *Flora*

M. U. J Le Verrier.
For his Researches in the Problem of Inverse Perturbations leading to the Discovery of the Planet *Neptune*.

Sir John Lubbock.
For his Researches in the Theory of Perturbations.

M. M Weisse.
For his Catalogue of Stars in Bessel's Zones

1849
Feb. 9 William Lassell, Esq.
The Gold Medal —For the construction of his Equatoreal Instrument and for the Discoveries made with it.

1850
Feb. 8. M. Otto von Struve.
The Gold Medal.—For his Paper on the Constant of Precession.

1851
Feb. 15 Dr. Annibale de Gasparis.
The Gold Medal.—For the Discovery of three Planets, *Hygeia*, *Parthenope*, and *Egeria*.

1852
Feb 13.

Dr C A F PETERS

The Gold Medal.—For his Papers on the Parallax of the Fixed Stars, and on the Constant of Nutation.

1853
Feb 11.

JOHN RUSSELL HIND, Esq

The Gold Medal.—For the Discovery of eight Planets, and other Astronomical Discoveries

1854
Feb 10

M CHARLES RUMKER

The Gold Medal.—For his Catalogue of 12,000 Stars, and for other Astronomical Services

1855
Feb 9

Rev W R DAWES

The Gold Medal.—For his Astronomical Labours generally

1856
Feb 8.

ROBERT GRANT, Esq , M.A.

The Gold Medal.—For his "History of Physical Astronomy"

1857
Feb 13

M. SCHWABE.

The Gold Medal.—For his Discovery of the Periodicity of the Solar Spots

1858
Feb 12.

Rev ROBERT MAIN, M A.

The Gold Medal.—For his various Contributions to the *Memoirs* of the Society.

1859
Feb 11

R. C CARRINGTON, Esq.

The Gold Medal.—For his "Redhill Catalogue of 3,735 Circumpolar Stars."

1860
Feb. 10

Professor P. A HANSEN.

The Gold Medal.—For his Lunar Tables.

1861
Feb. 8.

M. HERMANN GOLDSCHMIDT.

The Gold Medal.—For his Discovery of thirteen of the Minor Planets, and other Astronomical Discoveries.

1862
Feb 14. Warren De La Rue, Esq
The Gold Medal.—For his Astronomical Researches, and especially for his Application of Photography.

1863
Feb. 13. Professor Argelander.
The Gold Medal.—For his Survey of the Northern Heavens.

1865
Feb 10 Professor G. P Bond.
The Gold Medal.—For his work on the Comet of Donati, and other Astronomical Researches.

1866
Feb. 9. Professor Adams.
The Gold Medal —For his Contributions to the Development of the Lunar Theory

1867
Feb 8. W. Huggins, Esq , and Professor Miller.
The Gold Medal —For their Researches in Astronomical Physics.

1868
Feb 14. M. Le Verrier.
The Gold Medal.—For his Planetary Tables.

1869.
Feb 12. E. J. Stone, Esq.
The Gold Medal.—For his Rediscussion of the Transit of *Venus* in 1769, and his other contributions to Astronomy.

1870
Feb 11. M. Delaunay
The Gold Medal.—For his "Théorie de la Lune."

1872
Feb. 9. Signor Schiaparelli.
The Gold Medal.—For his Researches on the Connexion between the Orbits of Comets and Meteors.

1874
Feb. 13. Professor Simon Newcomb.
The Gold Medal.—For his Tables of *Neptune* and *Uranus*, and other contributions to Mathematical Astronomy.

1875
Feb. 12. Professor D'Arrest
The Gold Medal.—For his work entitled "Siderum Nebulosorum Observationes Havnienses, institutæ in Specula Universitatis per tubum sedecimpedalem Merzianum, ab anno 1861 ad annum 1867," and other Astronomical Works.